

**BULLETIN**  
*of the*  
**American Association of  
Petroleum Geologists**

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# THE BULLETIN

of the

## AMERICAN ASSOCIATION OF PETROLEUM GEOLOGISTS

JOHN L. RICH, *Third Vice-President in Charge of Editorial Work*

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The Bulletin of the American Association of Petroleum Geologists is published by the Association on or about the 15th of each month. Editorial and publication office, 504 Tulsa Building, Tulsa, Oklahoma, Post Office Box 1852.

The subscription price to non-members of the Association is \$15.00 per year (separate numbers \$1.50) prepaid to addresses in the United States, Mexico, Cuba, Porto Rico, Panama Canal Zone, Republic of Panama, Dominican Republic, Canary Islands, El Salvador, Argentina, Bolivia, Brazil, Colombia, Chile, Costa Rica, Ecuador, Guatemala, Honduras, Nicaragua, Peru, Hayti, Uruguay, Paraguay, Hawaiian Islands, Philippine Islands, Guam, Samoan Islands, Balearic Islands, and Spain.

Postage is charged extra: For Canada, 40 cents on annual subscriptions (total \$15.40), and for all other countries in the Postal Union, 70 cents on annual subscriptions (total \$15.70).

British agents: Thomas Murby & Co., 1 Fleet Lane, Ludgate Circus, London, E.C. 4.

Claims for non-receipt of preceding numbers of the BULLETIN must be sent to the business manager within three months of the date of publication in order to be filled gratis.

Back numbers of the BULLETIN can be ordered from the business manager at the following prices: Vol. 2, \$4.00; Vol. 3, \$5.00; Vol. 4, \$7.50, separate numbers, each \$3.00; Vols. 5 and 6, cloth bound, each \$12.00; Vols. 7 and 8, cloth bound, each \$11.50; separate numbers, each \$2.00, except Vol. 5, No. 2, \$3.50; Vols. 9, 10, and 11, cloth bound, each \$17.00; separate numbers, each \$1.50, except Vol. 9, numbers 1, 2, and 3, each \$3.00, Vol. 10, numbers 3, 11, and 12, each \$2.00, and Vol. 11, number 3, \$2.00. Special bound volume, *Geology of Salt Dome Oil Fields*, 787 pp., 230 illus., \$6.00. *Symposium, Theory of Continental Drift*, 240 pp., 29 illus., \$3.50.

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Association Headquarters—504 Tulsa Building, East Fifth Street at Cincinnati Avenue, Tulsa, Oklahoma.

Communications about the Bulletin, manuscripts, editorial matters, subscriptions, special rates to public and university libraries, publications, membership, change of address, advertising, and other Association business should be addressed to

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AMERICAN ASSOCIATION OF PETROLEUM GEOLOGISTS

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TULSA, OKLAHOMA

Entered as second-class matter at the Post Office at Tulsa, Okla., under the Act of March 3, 1879. Acceptance for mailing at special rate of postage provided for in section 1103, Act of October 3, 1917, authorized March 9, 1923.

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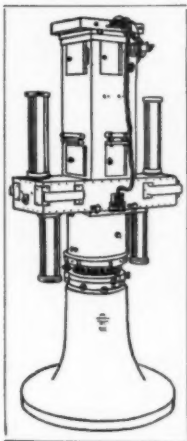
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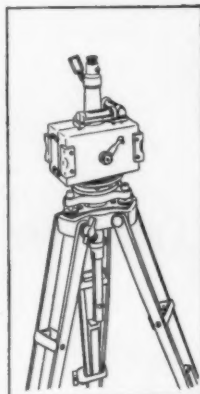
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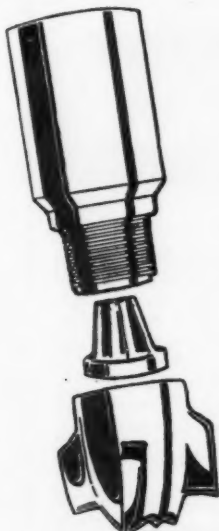
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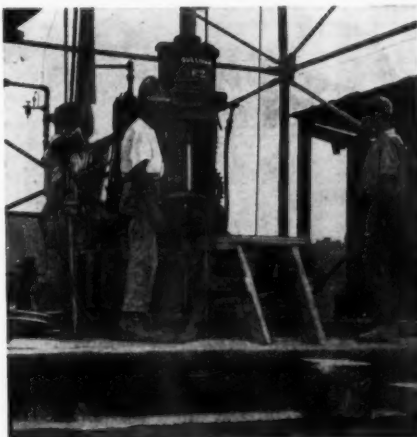
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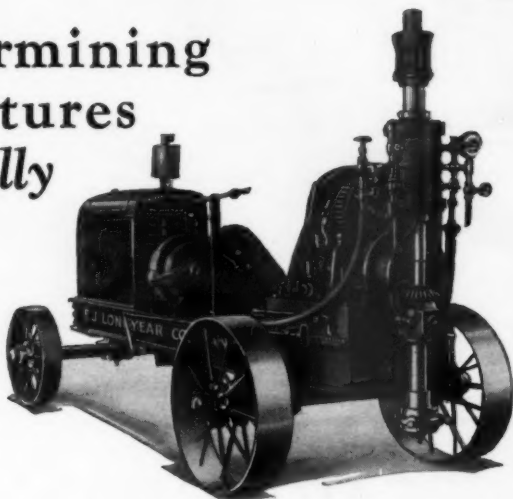
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of the

## AMERICAN ASSOCIATION OF PETROLEUM GEOLOGISTS

Vol. 12

MAY 1928

No. 5

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By CHARLES BREWER, JR.

### *Experiments Relating to Factors Causing Localization of Folds*

By ROBERT WESLEY BROWN

### *New Developments in Southern California Since 1923*

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GLENN D. ROBERTSON

### *California Oil Industry in 1927*

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By STANLEY HEROLD

BULLETIN  
of the  
AMERICAN ASSOCIATION OF  
PETROLEUM GEOLOGISTS

MAY 1928

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OIL FIELDS OF GERMANY<sup>1</sup>

WALTER KAUNHOWEN<sup>2</sup>

Houston, Texas

---

ABSTRACT

In Germany there are three different oil provinces, namely, the North German, the Rhenish, and the Subalpine. A geological summary of these provinces is given. The different oil fields are described as to the stratigraphy and structure. An explanation is given of the origin of the oil in the different provinces. It originated at various ages but under the same facies and paleogeographic conditions.

The development of the German oil industry, the output of the different fields, the properties of the oil, the production methods, and petroleum laws are indicated.

Since 1920 the German oil production has steadily increased. Nearly all oil at present produced in Germany comes from the North German oil province, where it is found in the vicinity of salt domes under conditions similar to those in the Gulf coastal plain of the United States.

---

GENERAL VIEW OF THE GERMAN OIL PROVINCES

In Germany there are three different districts where oil is found. These districts differ so much in location, stratigraphy, and structure, that they may be treated as separate oil provinces. Each has its own special conditions. These provinces are (1) the North German, (2) the Rhenish, and (3) the Subalpine province.

The *North German oil province* (Fig. 1) comprises an area of about 61,775 square miles (160,000 square kilometers). It covers the largest part of the North German Plain and consists of parts of the following

---

<sup>1</sup>Manuscript received by the editor, February 15, 1928.

<sup>2</sup>Gulf Production Company, 408 Gulf Building. Formerly collaborator at the Oil Research Institute of the State Mining Academy of Clausthal (Germany). Introduced by Donald C. Barton.

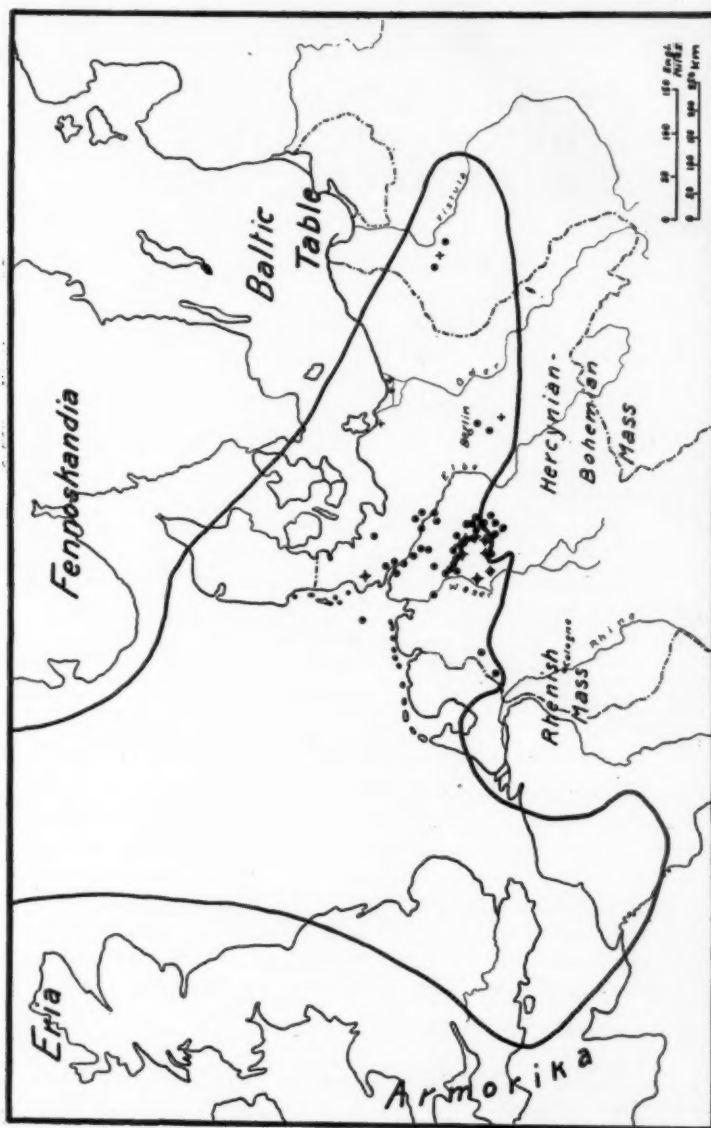


FIG. 1. Paleogeographic map of the North German oil province in the lowest Cretaceous (Wealden) showing the shore line (black line), the arrangement of salt domes (black dots), oil occurrences (crosses), and salt domes with oil production (crossed black dots). Dash-dotted line, German frontier.

German states: Prussia, Brunswick, Oldenburg, Mecklenburg, Hamburg, Bremen, and Lübeck.

In this province, oil occurs chiefly on the flanks of salt domes. This is particularly true in the Prussian province of Hanover where 99.9 per cent (710,000 barrels) of the total German output was produced in 1926. The productive horizons are chiefly of Jurassic and Cretaceous age.

The *Rhenish oil province* (Fig. 2) comprises about 5,020 square miles (13,000 square kilometers) and extends on both sides of the Rhine from the vicinity of Bâle up to the vicinity of Mainz. This district is crossed by the German-French frontier. The Alsacian oil occurrences, with the oil field of Pechelbronn, belong to France. It is here that almost the entire oil output of France (amounting to 478,000 barrels in 1926) is produced. On German territory oil has been found in various places in the states of Baden, Hessen, and the Palatinate, but so far no paying production has been attained. The drilling of test wells is now going on. The oil comes from the Oligocene. As to the structure, oil is found in slightly inclined monoclines which are cut by faults.

The *Subalpine oil province* (Fig. 3) is situated on the northern border of the Alps and extends from Switzerland to Bavaria, Austria, and Czechoslovakia. Germany has a share in this oil province in Bavaria only and her part amounts to 11,580 square miles (30,000 square kilometers). Oil has been produced in this district only at Tegernsee and in very small amounts. Seepages of oil occur in strata of the Upper Cretaceous. Near Passau on the Danube and in Austria many places are known to contain natural gas and oil from the Miocene, but as yet no use has been made of it.

#### NORTH GERMAN OIL PROVINCE

##### GEOLOGIC CONDITIONS

##### OUTLINE

The North German oil province is situated in a geosyncline which began to form late in the Permian. During the Mesozoic and the Tertiary sediments more than 9,850 feet (3,000 meters) in thickness were amassed here. At the time of the Lower Cretaceous the southern border of this basin approximately coincided with the shore line shown in Figure 1.

The sediments of this geosyncline consist chiefly of marine deposits of shallow-sea water which during the Tertiary changed into brackish,

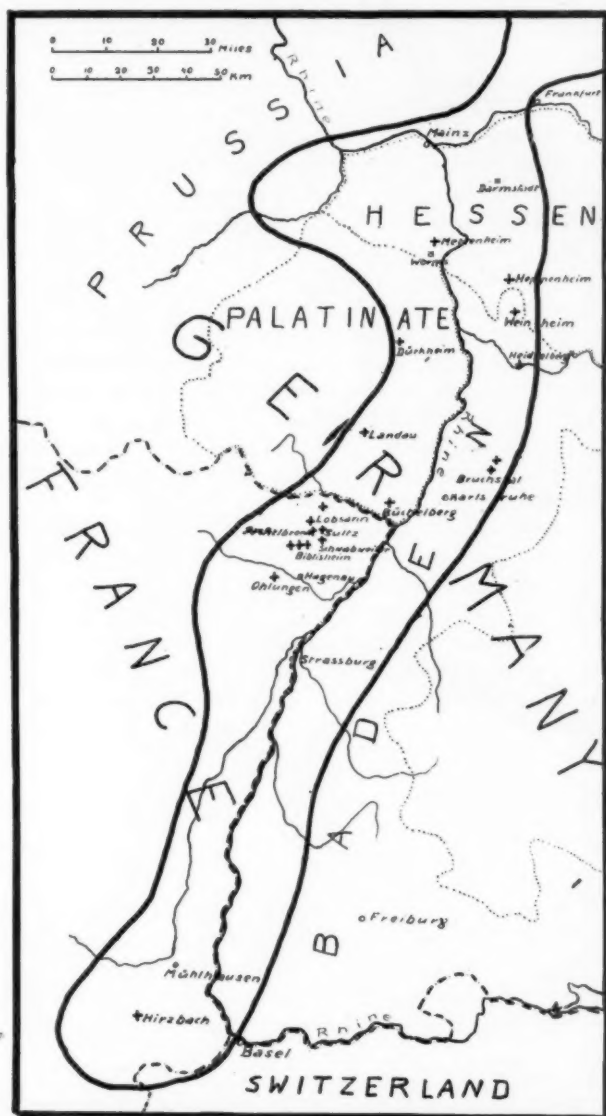


FIG. 2. Paleogeographic map of the Rhenish oil province in the Oligocene showing shore line (black line), oil occurrences (crosses), and political frontiers.



FIG. 3. Paleogeographic map of the Subalpine oil province in the Lower and Middle Miocene showing shore lines (black lines), oil occurrences (crosses), and political frontiers.

fresh-water, and at last continental deposits. Temporary fillings of the basin are indicated by thin coal seams that date from the beginning of the Cretaceous, and by considerable deposits of lignites in the Eocene and Miocene. At several times there has also been a formation of rock salt and gypsum favored by an arid climate, for example, in the Upper Permian, in the Lower, Middle, and Upper Triassic, and in the Upper Jurassic. All these salt beds with the exception of those of the Middle Triassic are closely connected with red and colored clays. Similar phenomena are also known in the Rhenish province (6 and 11),<sup>1</sup> in the Subalpine province (10, p. 23), in the Mid-Continent oil fields (29, p. 1,075), in the fields of Burma (24, p. 565) and in many other oil fields of the world.

A generalized stratigraphic section through the oil-bearing North German geosyncline is shown in Table I. The thickness of the sediments gradually increases from the south, the border of the basin, to the north, the central part of the basin. Outcrops of the Mesozoic are found only near the southern border, whereas toward the north the Mesozoic is buried by Tertiary and Pleistocene strata. Therefore very little is known about the subsurface structure. To reach definite knowledge about it, one is completely dependent on the result of wells and geophysical exploration.

#### SALT DOMES

Among the most characteristic features of the subsurface structure of the North German plain are the salt domes. Domes of the Hanoverian

<sup>1</sup>The numbers refer to the bibliography at the end.

type, such as are mentioned in this paper, show a very close analogy to the salt domes of Texas and Louisiana, southern Roumania, and the Persian Gulf. They have been described at various times in the English language by Donald C. Barton (1), H. Stille (25), and W. A. J. M. van

TABLE I  
GENERALIZED STRATIGRAPHIC SECTION IN NORTHWEST GERMANY

	Formations	Lithologic Character	Facies	Average Thickness	
				Feet	Meters
Pleistocene	Diluvium	Sands, gravels, boulder clay, loess, peat	Glacial, fluvio-glacial, inter-glacial	330	100
	Pliocene	Sands, gravels, clays, sandstones, lignites	Continental, piedmont, river and fresh-water deposits	1,300	400 max.
	Miocene	Clays with mica, sands, lignites	Continental and marine	990	300 max.
Tertiary	Oligocene	Clays with limestone nodules, greensands, sands, and marls with phosphatic concretions	Chiefly marine	800	250
	Eocene	Clays, volcanic ash, red sandstone	Marine and continental	160-330	50-100
	Paleocene	Limestones, conglomerates	Marine	230-660	70-200
	Senon	Light-colored limestones and chalk with flint nodules, conglomerates	Marine	500-660	150-200
	Emscher	Chiefly gray marls	Marine	600-990	200-300
Cretaceous	Turon	Limestone and marls	Marine	990	300
	Cenoman	Marls and limestones	Marine	200	60
	Gault	Dark shales with siderite nodules	Marine	660-1,300	200-400
	Neokom (Wealden)	Blue and dark shales, sandstones, thin coal seams	Marine, brackish-water, estuarine	660-1,300	200-400

TABLE I—Continued

	Formations	Lithologic Character	Facies	Average Thickness	
				Feet	Meters
J u r a s s i c	Malm	Red shales, gypsum and rock salt beds, light limestones, and marls	Saline, brackish-water, marine	660- 1,640	200- 500
	Dogger	Dark shales, siderite nodules	Marine	500- 800	150- 250
	Lias	Dark shales, marls, siderite nodules, oil shales, oolitic iron ores	Marine	600- 980	170- 300
T r a s s i c	Keuper	Red and green clays and marls, gypsum, sandstones, coal sandstones	Saline and continental	1,300 max.	400 max.
	Muschelkalk	Limestones and marls, anhydrite, and dolomite	Marine	600- 980	170- 300
	Buntsandstein	Red sandstones, sandy clays, colored clays and marls, gypsum and salt beds	Chiefly continental, playa-like	2,300- 3,300	700- 1,000
P e r m i a n	Zechstein	Rock salt, potash salt, anhydrite, and other salt beds, salt clay, dolomite, limestone, bituminous shales	Marine	660- 4,300	200- 1,300
	Rotliegendes	Red sandstones and conglomerates, thin coal seams, porphyry	Continental	1,600- 3,300	500- 1,000

Waterschoot van der Gracht (27). Therefore, only the most important facts need be mentioned here.

*Location and size.*—Nearly forty salt domes are known in Germany (Fig. 1). They differ very much in size and shape. Some have circular or oval horizontal sections with a diameter of 3,300 feet (1 kilometer) only. Others show a length of many miles with a breadth of only a few hundred feet. In this case they may be regarded as dikes (compare the drawings of German salt domes published by Donald C. Barton (1)). In many of the domes one flank is overturned or bent like a swan's neck, as described by Sidney Powers (18, p. 42) in connection with the Keechi salt dome in Texas.

In the typical Hanoverian salt domes the salt forms a core which is upthrust between strata much younger than the salt. Farther south the structures are normal anticlines which contain the salt conformably interbedded between Lower Permian and Lower Triassic.

*Arrangement of salt domes.*—Figure 1 shows that the salt domes in northern Germany are arranged in a distinctive manner, that is, in two alignments, which play an important part in the structure of Germany. One alignment, called the Hercynian, strikes northwest; the other, called the Rhenish, strikes northeast.

In the northwest alignment are a line of salt domes following the course of the Aller and lower Weser rivers. A second line of salt domes, parallel to the former, follows the course of the lower Elbe. Salt domes may be found where the Hercynian and the Rhenish alignments cross. It may be regarded as a fact that in the arrangement of salt domes in northern Germany, zones of structural weakness are favored and that the upthrust of the salt domes has taken place on these lines of deformation. This arrangement is also confirmed by the fact that these deformation lines change in their trend into normal anticlines in the southern part of the North German basin.

*Age of the salt.*—The salt of the domes belongs to the Upper Permian. This is indicated by the fact that salt beds of the same petrographic character, stratigraphic order and thickness as in the salt domes are found in Middle Germany lying conformably between Lower Permian and Lower Triassic. A stratigraphic section of the different salt beds of the Upper Permian as they occur in North German salt domes is shown in Table II. They contain valuable potash salts. As the Permian salts in many salt domes have been intruded not only into Mesozoic but also into Tertiary and Pleistocene rocks, they must have been upthrust from depths of more than 10,000 feet (3,000 meters). Thus the potash salts were uplifted into such shallow depths that they can be mined in northern Germany.

The *cap rock* chiefly consists of gypsum and of the residuals left behind by leaching the various salt rocks. This gypsum has been produced by the hydration of anhydrite which is found in many of the salt beds. Lime and sulphur which occur commonly in the cap rocks of the American salt domes are unknown in the gypsum cap of the German salt domes, neither does the writer know them in the Roumanian salt domes.

The *internal structure* of the North German salt domes is well known because of the numerous potash mines. The strata are exceedingly folded

TABLE II  
GENERAL STRATIGRAPHIC SECTION OF THE UPPER PERMIAN SALT SERIES  
IN HANOVER

		<i>Lithologic Character</i>	<i>Average Thickness</i>	
			<i>Feet</i>	<i>Meters</i>
Salt Series of the Upper Permian Zechstein	"Youngest"	Youngest rock salt	328	up to 100
		Pegmatitic anhydrite	2.6-7.1	0.8-2.2
	"Younger"	Red salt clay	23-46	7-14
		Rock salt with red and blue nests of clay	16-33	5-10
		Red or white sylvinite (potash salt bed)	9.8-16	3-5
		Rock salt with thin beds of anhydrite	40-60	13-19
		Red rock salt with dark sands of anhydrite and kieserite	26-52	8-16
		Pure rock salt in thick bands	9.8-81	3-25
		White sylvinite (potash salt bed)	13-26	4-8
		Rock salt and kieserite	0.9-2.5	0.3-0.75
		Red to yellowish rock salt	65-98	20-30
		White to gray rock salt banded distinctly by anhydrite	19-49	6-15
		Gray, red, and violet rock salt banded with anhydrite	6.5-13	2-4
		Dark gray "main" anhydrite	30-80	9-26
		Gray salt clay	16-49	5-15
	"Older"	Banded kieserite, sylvine, halite (potash salt bed)	30-40	9-13
		Bituminous rock salt	984-2,300	300-700

and highly contorted, although the younger rocks surrounding the salt core show for the most part a slightly inclined or nearly horizontal position (1, p. 1,254).

The opinions of the German geologists differ widely regarding causes of the *origin of the upthrust* of the salt domes. Some of them, particularly H. Stille, believe that this upthrust has taken place episodically, is bound to orogenic phases, and is caused by tangential

pressure. Other writers, for example, Harbort and Gripp, believe that the upthrust is progressing continually and is caused by the vertical pressure of the sediments accumulating on the salt.

Regarding the *age of the salt domes* it is known that some occurred in the Lower Cretaceous, for the Permian salt of these domes is unconformably overlapped by the Lower Cretaceous. It is possible that even in the Middle Jurassic the upthrust of the salt core could be noticed.

In the main, brine springs, halophytic plants, and sink-holes were the features which led to the prospecting and drilling of salt domes. In some places sporadic occurrences of Mesozoic rocks in the Pleistocene plain indicated the existence of a salt dome below the surface, as near Lüneburg and Segeberg. These occurrences may be compared with the mounds of the salt domes of the Gulf Coast of the United States. On most of the North German salt domes, however, such mounds are unknown.

#### OIL FIELDS

##### GENERAL OUTLINE

The commercially exploited oil fields of northern Germany are on the flanks of the salt domes just mentioned.

Oil is now being produced at the salt domes of Wietze, Nienhagen-Hänigsen, and Oberg (Fig. 4).

In former years oil was produced also at the salt domes of Oelheim, Hoheneggelsen, Sehnde, Hordorf, Klein-Schöppenstedt, and Heide.

Natural gas has been produced in large quantities at Neuengamme near Hamburg, but the existence of a salt dome could not be proved, either by wells or by geophysical methods (8, 9).

The occurrence of oil has been proved by wells near the salt domes of Hope-Lindwedel, Sottorf near Hamburg, and Gross-Varlingen near Husum. In these districts oil will soon be produced in large quantities.

##### DEVELOPMENT OF THE NORTHWESTERN GERMANY OIL INDUSTRY

The earliest reference to the occurrence of oil in northern Germany goes back to the middle ages. As early as 1546, George Agricola, the classical writer on mining and geology, states that oil outcrops are to be found near Hänigsen and in the free state of Brunswick. At the same time he and other ancient writers observe that this oil is gathered by the inhabitants in pits and, after the water has been skimmed off, is used for the painting of door posts and for wheel-grease. These pits where oil was trickling out and was gathered were called by the people

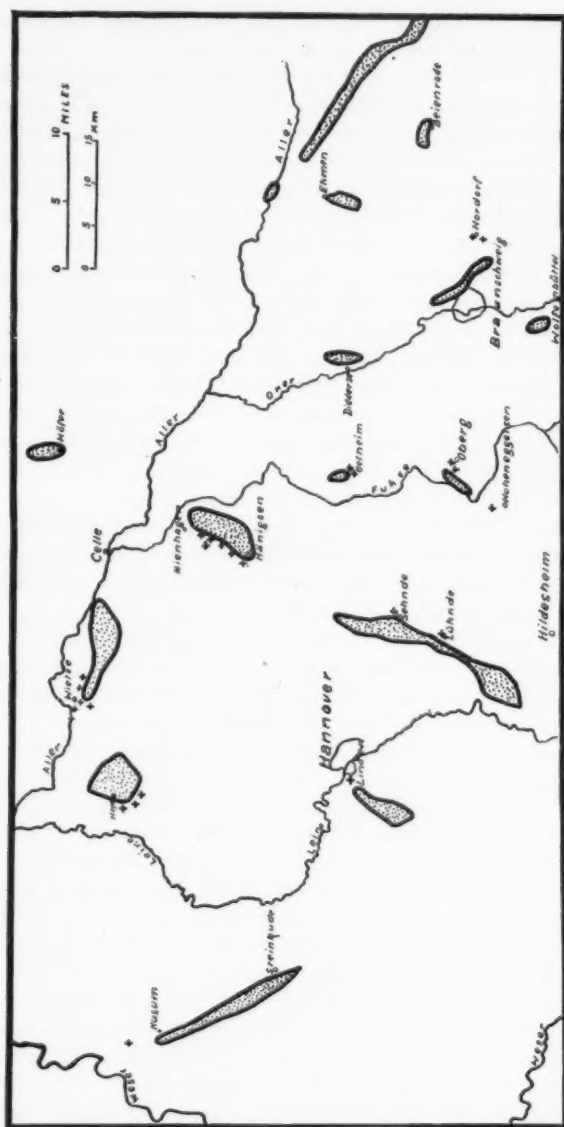


FIG. 4. Map of the salt domes of southern Hanover showing extension of the top of the alt cores (dotted areas) (after Stille) and oil occurrences.

"Teerkuhlen" (tar pits). They were the starting point for the later development of the oil fields by wells.

In 1859 the first oil well was drilled on behalf of the Hanoverian government in the tar pit of Wietze, in the same year when E. L. Drake founded the American oil industry near Titusville. But this well, like others which were drilled by English, French, and Belgian companies in the early sixties, was a failure. The wells were operated with insufficient technical equipment and without any consideration of the geological conditions, which were unknown at that time. The wells were drilled only near the outcrop of the oil-bearing strata to depths ranging from 330 to 660 feet (100 to 200 meters).

In 1881 a favorable change in the German oil industry took place, for in this year a Bremen firm succeeded in bringing in several flowing wells near Oelheim, also in the immediate vicinity of tar pits. The production was increased in a short time. An oil fever was caused, many companies were founded, but the wells were drilled on such a small area and in such an improper way, that in a short time the oil horizons were flooded by water and the production decreased very rapidly.

Meanwhile wells had also been drilled in the oil field of Wietze; therefore, the total output of oil in northern Germany remained approximately the same. In 1900, however, a new oil horizon was struck at Wietze at depths ranging from 660 to 1,000 feet (200 to 300 meters), furnishing a very valuable light oil. The oil industry of Germany received a new impulse. The production was doubled, numerous new companies were formed, and the leading banks began to take an interest in the industry.

In 1903 a railroad was opened through the oil field and in 1904 legislation gave the first instructions about operating oil wells and the shutting-off of water.

In 1907 all these small companies at Wietze were incorporated under the leadership of several German banks. Thus the production there was practically united and rational methods could be introduced. The production increased more and more and as several profitable holes were drilled in the district of Hänigsen, which had been completely neglected up to this time, German oil production reached its highest point in 1909 with a yearly output of 850,000 barrels (113,518 tons).

The years of the war were naturally unfavorable for oil production because of lack of men and materials. In spite of the increased number of companies (156 in 1918 against 33 in 1913) no new oil field could be opened.

In 1919 the introduction of oil mining in the field of Wietze, which had practically lost its gas, resulted in maintaining the production of this field during the following years.

In 1922 another important event in the development of the north-west German oil industry took place. In this year a comparatively big gusher (for German conditions) was successfully completed in the northern part of the oil field of Hänigsen-Nienhagen, furnishing an initial daily production ranging from 1,500 to 2,250 barrels (200 to 300 tons). This well was followed by several equally productive ones, and very soon the oil production of the Hänigsen-Nienhagen field surpassed that of Wietze, so that now it furnishes the greater part of the German output. These wells were of supreme importance for the German oil industry because their production greatly surpassed the previous average German production. On the other hand these wells were not drilled close to the flank of the salt dome, as were earlier holes, but farther away from the flank. Therefore they struck the oil-bearing strata at greater depths ranging from 2,320 to 2,640 feet (700 to 800 meters) instead of 660 to 990 feet (200 to 300 meters) as formerly. It was now proved that by drilling holes deeper than had ever been ventured before, it would be possible to discover considerable amounts of oil. Shortly after the war, another field was developed near Oberg, the production of which is steadily increasing (Table III).

All these circumstances were not only causing a continuous increase of the oil production since 1920, amounting to 171 per cent within this time, but also an increase of exploration work and wildcatting.

#### OIL FIELD OF WIETZE

*Structure.*—The oil of Wietze occurs (Figs. 4 and 5) on the northwest end of a salt dome striking in the Hercynian direction and having a length of 7.5 miles (12 kilometers) and a breadth ranging from  $\frac{5}{8}$  to 2 miles (1 to 3 kilometers). The horizontal section of the salt dome slightly resembles a scythe. Its gypsum cap extends down to 164 feet (50 meters) below the surface and has a thickness ranging from 82 feet (25 meters) to 164 feet (50 meters). The salt core consists of strongly contorted rock salt and potash salts and has not been penetrated at a depth of 5,249 feet (1,600 meters). The northern as well as the southern flanks of the salt dome dip steeply toward the south; therefore, it is overturned toward the north.

South of the salt dome (Fig. 5), occur gently dipping beds ranging in age from Middle Jurassic to Lower Cretaceous. North of the salt

TABLE III

## PRODUCTION OF THE DIFFERENT GERMAN OIL FIELDS

Name of the Field	NORTH GERMAN OIL PROVINCE						Tegernsee: Sub- alpine Oil Province (Bavaria)	Total Production of Germany	
	Wietze	Nienha- gen- Hänigsen	Oelheim	Oberg	Heide in Holstein	Linden near Hanover			
Year	Barrels* Metric Tons	Barrels Metric Tons	Barrels Tons	Barrels Tons	Barrels Tons	Barrels Tons	Barrels Tons	Barrels	Metric Tons
1873	289 38.5							289	38.5
1874	289 38.5							289	38.5
1875	289 38.5							289	38.5
1876	338 45							338	45
1877									
1878									
1879	353 47							353	47
1880	1920 256							1920	256
1881	21600 2871		22400 2990					44000	5861
1882	44900 5985		37770 5100		30 4			82700	11085
1883	18500 2495		7438 1036				462 61.75	26400	3531
1884	27300 3631		9885 1404				615 82	37800	5035
1885	563 75		19600 2620				244 32.5	20400	2728
1886	2080 277		17900 2382			90 12	178 23.75	20300	2715
1887	3450 459		15610 2078			112 15		19200	2552

## OIL FIELDS OF GERMANY

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TABLE III—Continued

Name of the Field	NORTH GERMAN OIL PROVINCE						Tegernsee: Sub-alpine Oil Province (Bavaria)	Total Production of Germany	
	Wietze	Nienhagen-Hanigsen	Oelheim	Oberg	Heide in Holstein	Linden near Hanover			
Year	Barrels* Metric Tons	Barrels Metric Tons	Barrels Tons	Barrels Tons	Barrels Tons	Barrels Tons	Barrels Tons	Barrels	Metric Tons
1888	8600 1112.5		12390 1650			56 7.5		20800	2770
1889	11800 1567		11100 1486			45 6		23000	3059
1890	6250 833		10590 1413			23 3		16900	2289
1891	9800 1311		8850 1182			38 5		18700	2498
1892	6200 826		5680 758			7.5 1		11900	1585
1893	6760 897		3470 464			30 4		10290	1365
1894	8400 1088		3800 509			23 3		12000	1600
1895	6630 886		5430 723			23 3		12100	1612
1896	6050 809		5240 701			15 2		11300	1512
1897	11600 1546		7890 1054					19500	2600
1898	13090 1740		6030 805					19000	2545
1899	19010 2536		6500 869					25500	3405
1900	203000 27042		5140 689					208000	27731
1901	178000 23266		6230 832					180900	24098
1902	216000 28797		5430 723					221000	29520
1903	306000 40746		7390 987					312000	41733

TABLE III—Continued

Name of the Field	NORTH GERMAN OIL PROVINCE						Tegernsee: Sub- alpine Oil Province (Bavaria)	Total Production of Germany	
	Wietze	Nienha- gen- Hanigsen	Oelheim	Oberg	Heide in Holstein	Linden near Hanover			
Year	Barrels* Metric Tons	Barrels Metric Tons	Barrels Tons	Barrels Tons	Barrels Tons	Barrels Tons	Barrels Tons	Barrels	Metric Tons
1904	495000 66079	880 117	9990 1320		593 79			506000	67604
1905	417000 55579	3750 499	12450 1663					434000	57741
1906	430000 57379	3760 502	9800 1315				983 131	445000	59327
1907	589000 78377	2600 347	10800 1446		638 85		975 130	605000	80385
1908	850000 110536	6080 812	12400 1654				1260 168	850000	113170
1909	790000 105752	45600 6114	12400 1654				2280 304	850000	113822
1910	684000 91283	140400 18666	7840 1047					824000	110996
1911	672000 89786	60200 8032	6190 826		38 5			738000	98644
1912	613000 81621	38900 5191	4960 661		38 5			657000	87443
1913	476000 63522	53500 7146	3820 510		30 4			534000	71178
1914	395000 52836	58200 7771	3860 515		30 4			459000	61134
1915	364000 48358	52900 7061	3580 478		30 4			419000	55923
1916	330000 44023	50500 6734	3680 486		15 2			385000	51245
1917	280500 37361	43900 5844	3080 411		45 6			327000	43622
1918	240800 32039	42000 5600	2910 388		15 2			285000	38029
1919	246500 32758	30200 4025	3320 442		45 4			280000	37353

TABLE III—Continued

Name of the Field	NORTH GERMAN OIL PROVINCE						Tegernsee: Sub-alpine Oil Province (Bavaria)	Total Production of Germany	
	Wietze	Nienhagen-Hanigsen	Oelheim	Oberg	Heide in Holstein	Linden near Hanover			
Year	Barrels* Metric Tons	Barrels Metric Tons	Barrels Tons	Barrels Tons	Barrels Tons	Barrels Tons	Barrels Tons	Barrels	Metric Tons
1920	231000 30700	26800 3596		4780 631			674 90	264000	35045
1921	257000 34221	23300 3116		7230 965			645 86	287000	38389
1922	235000 31266	73000 9751		6750 901			549 73	314000	41905
1923	255000 34058	114000 15208		10850 1452			390 52	381000	50770
1924	286000 38045	151900 20230		7800 1024			397 53	445000	59352
1925	306000 40762	280000 37289		7900 1053			150 20	595000	79150
1926	332000 44218	357000 47776		25000 3344			217 20	715000	95367

\*The figures in metric tons are official, the figures in barrels are approximate (1 ton equals about 7.5 barrels).

dome, however, these beds have a maximum dip of  $70^{\circ}$ . Between 656 and 1,312 feet (200 and 400 meters) in depth these strata are suddenly cut on the north side of the salt by a thrust plane dipping from  $20^{\circ}$  to  $35^{\circ}$  N. Under this thrust plane there are older strata, namely, Upper Triassic and Lower Jurassic, dipping from  $55^{\circ}$  to  $85^{\circ}$  away from the salt core. This thrust plane cuts several smaller strike- and dip-faults, extending radially and concentrically from the flanks of the salt dome.

North of the salt dome the Lower Cretaceous is unconformably overlapped by the Upper Cretaceous (Senon), dipping  $15^{\circ}$  N. North and south of the salt core the Senon is unconformably overlapped by the Tertiary, dipping from  $5^{\circ}$  to  $10^{\circ}$  away from the salt.

The structure of this salt dome indicates that it must have originated for the most part in pre-Senonic time. After the Senonic only minor orogenic movements have taken place in the Tertiary and Pleistocene.

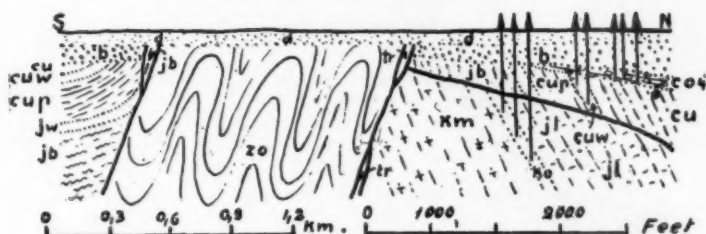


FIG. 5. Section across the Wietze salt dome and oil field (after Kraisz): zo, salt series of the Upper Permian, folding generalized; tr, Triassic; km, Middle Keuper; ko, Upper Keuper; jl, Lower Jurassic; jb, Middle Jurassic; jw, Upper Jurassic; cuw, Uppermost Jurassic; cuw, Lowest Cretaceous (Wealden); cu, Lower Cretaceous; co4, Upper Cretaceous (Senonian); b, Tertiary; d, Pleistocene (Diluvium). Black lines, faults and thrusts; dotted lines, formation boundaries.

**Stratigraphy and oil horizons.**—Near Wietze oil is found on the overturned north and northwest flanks of the salt dome but nowhere on the other flanks; it is found there in several stratigraphic horizons.

The oldest oil horizon belongs to the Upper Triassic (Rät). It is also the deepest horizon of the whole field, the depths of the wells ranging from 1,089 to 1,155 feet (330 to 350 meters). The oil is of light grade, although all other oil horizons of Wietze contain heavy oil. The reservoir rock consists of two sandstone horizons, 63 and 8 feet in thickness (19 and 2.5 meters), separated by a bed of clay 33 feet (10 meters) thick.

A second oil horizon belongs to the Upper Dogger (Middle Jurassic), a third to the Lower, and a fourth to the Upper Malm. Here also sands are the reservoir rocks, but these horizons are of little importance.

Of the greatest importance, however, is the fifth horizon, which is widespread and rich in oil. It belongs to the Wealden, a brackish-water and estuarine deposit between the Jurassic and the Cretaceous. This oil zone dips from  $40^{\circ}$  to  $45^{\circ}$ , in places  $60^{\circ}$ . The thickness of the total Wealden ranges from 200 to 260 feet (60 to 80 meters). In it may be recognized four oil horizons, forming lenticular cross-bedded sands interbedded with shales. The thickness of the lenses ranges from 3.3 to 40 feet (1 to 12 meters). On an average it amounts to about 20 feet (6 meters). Oil occurs in the sands only; the interbedded shales are free from oil. Below the oil sands there are red marls of Upper Jurassic age. Wells for the exploitation of these Wealden horizons attain a depth ranging from 660 to 990 feet (200 to 300 meters). It is this horizon which is exploited by the well known mining methods with shafts and galleries.

A sixth oil horizon in the Upper Cretaceous is of little importance. Likewise oil occurrences in the Tertiary and Pleistocene are unimportant.

In the oil fields of Wietze two kinds of *salt water* are known: edge water from the deeper parts of the oil sand and top water from the Tertiary and the Pleistocene.

The *geothermal conditions* are shown in the two potash salt mines of the salt dome. The mine at a distance of only 1,300 feet (400 meters) from the oil field shows a very rapid heat increment, but the mine situated 3.5 miles (7 kilometers) away has nearly normal geothermal conditions.

*Properties of oil.*—In the Wietze field there are two different kinds of oil, light and heavy. Light oil occurs in the Upper Triassic (Rät) only. It has an olive-green color and a specific gravity of 0.885 to 0.920 at 20° C. The heavy oil comes from the higher horizons. It has a dark brown color and a specific gravity of 0.935 to 0.950. The detailed chemical and physical properties are shown in Table IV.

*Exploitation.*—The area of the Wietze field now being exploited is 1.9 square miles (5 square kilometers). In this area about 1,500 wells have been drilled having an average depth of 825 feet (250 meters). There are also two shafts with a depth of 792 feet (240 meters). The annual yield of this field is shown in Table III. About half of the present production is gained by mining and the other half is produced by wells through pumping and bailing. Scarcely any flowing wells are drilled now because the oil-bearing strata have already lost too much gas.

From 1874 to the end of 1927 this field has yielded a total output of about 11,190,000 barrels (1,495,987 tons) of oil, making a total production of 2.25 barrels (0.3 tons) per 10.8 square feet (1 square meter). The average life of these wells ranges from 6 to 8 years and their average annual output is about 750 barrels (100 tons) per well.

#### OIL FIELDS OF NIENHAGEN-HÄNIGSEN

*Structure and stratigraphy.*—This oil deposit occurs on the west flank of a salt dome striking north-northeast (Figs. 4 and 6). The length of the salt dome is about 5 miles (8 kilometers) and the breadth about 2 miles (3 kilometers). Oil in paying quantities has been found only on the overturned west flank of the salt dome.

The rocks surrounding the salt dome at these overturned strata are Triassic, Jurassic, Cretaceous, and Tertiary. The Mesozoic sediments dip about 85° W. (Fig. 6). Farther from the salt dome the dip increases to 25° W. The Lower Cretaceous lies unconformably on the Middle

TABLE IV

## PROPERTIES OF GERMAN CRUDE OILS

<i>Name of the Field</i>	<i>Wietze</i>	<i>Wietze</i>	<i>Nienhagen</i>	<i>Nienhagen</i>
Geologic formation	Upper Triassic (Raet)	Lower Cretaceous (Wealden)	Middle Jurassic (Dogger)	Lower Cretaceous (Neokom)
Color	olive-green	dark brown	olive-green	coffee-brown
Flashing point (open tests) °C.	27	121	82	81
Specific gravity at 20° C.	0.882	0.946	0.901	0.914
Viscosity at 20° C. (Engler)	5.63	183.6	18.1	24.0
Cold-test (Schultze)	5 mm. at -3°	1 mm. at -15°		17 mm. at 20°
Asphalt	0.28%	1.42%		0.05%
Distillation commenced at °C.	118	245	220	130
Distilling below 150°	2.0%			0.5%
150° - 250°	17.5%		5.0%	9.5%
250° - 275°	23.5%	1.5%	10.5%	13.8%
275° - 300°	31.5%	6.0%	15.0%	19.5%
300° - 325°	38.5%	12.5%		25.2%
325° - 350°	51.0%	26.0%	35.5%	39.2%

Jurassic, the Upper Cretaceous unconformably on the Lower Cretaceous, and the Tertiary overlaps unconformably all the other strata including the Permian (Fig. 6). The Mesozoic is cut by many faults trending in both Rhenish and Hercynian alignments. In the north part of the field the Mesozoic forms a gentle northwest-striking anticline which is cut by the west flank of the salt dome. This anticline has a breadth of about 1 mile (1.5 kilometers).

The formation of the salt dome may have taken place in the Lower or Middle Dogger. Most of the faults were produced in the pre-Senonic age.

*Oil horizons.*—In the southern part of the field oil is found in irregular hollow spaces, fissures, nests, and joints occurring in very different rocks. These may be explained as breccias caused by leaching and subsidence of Triassic rocks.

In the north part of the field, however, oil occurs in an anticline in stratified sands. Here three different oil horizons are of special importance, the Lower Jurassic, the Lower Dogger, and the Lower Cretaceous. The last contains the main oil reservoir, which is exploited by wells with a maximum depth of 2,640 feet (800 meters).

Oil sands of less importance are also found in the Upper Dogger, the Senon, the Tertiary, and the Pleistocene.

The oil in the main reservoir in the Lower Cretaceous is dark green, thick, generally free of asphalt, and has a specific gravity of 0.911 to 0.924 at 20° C. A detailed analysis is given in Table IV. This oil contains large quantities of gas, composed of 92 per cent methane, about 3 per cent other paraffines, 2.5 per cent nitrogen, and small quantities of CO, CO<sub>2</sub>, O<sub>2</sub>, and H<sub>2</sub>. Helium was found in traces only.

Salt water occurs in various parts of the field. Most of it is edge water. Analyses of different samples have been published by the writer (14). Analyses of four characteristic samples are shown in Table V.

The exploitation of this field began in 1903. Formerly the wells ranged in depth from 600 to 660 feet (150 to 200 meters). In 1922 and 1923 flowing wells which had been drilled in the northern part of the field reached depths of 2,640 to 3,300 feet (800 to 1,000 meters), yielding initial productions ranging from 1,500 to 2,250 barrels (200 to 300 tons) daily. Almost all of the present production comes from the north part of the field. The area now being exploited contains about 2.3 square miles (6 square kilometers). In this area 640 wells had been drilled up to 1925. The total production from 1906 to 1926 amounts to 1,650,000 barrels (220,811 tons), showing a total output of 0.225 barrel per 10.75 square feet (0.03 ton per square meter). The rapid development of production is shown in Table III.

#### OIL FIELD OF OBERG

On the east flank of a salt dome near Oberg, striking north-northeast and having a length of 2 miles (3 kilometers), a dome of Jurassic rocks is unconformably overlapped by the Lower Cretaceous (Wealden) (Figs. 4 and 7).

Oil occurs in two different horizons, the Lower Dogger and the Lower Cretaceous. The reservoir rocks in the Dogger are sand lenses bedded in clays. The oil-bearing rocks of the Dogger are not exposed but the Wealden oil horizon crops out. The Wealden contains a heavy oil which is not yet exploited. Only the Dogger horizon has been exploited and it yields a valuable light oil.

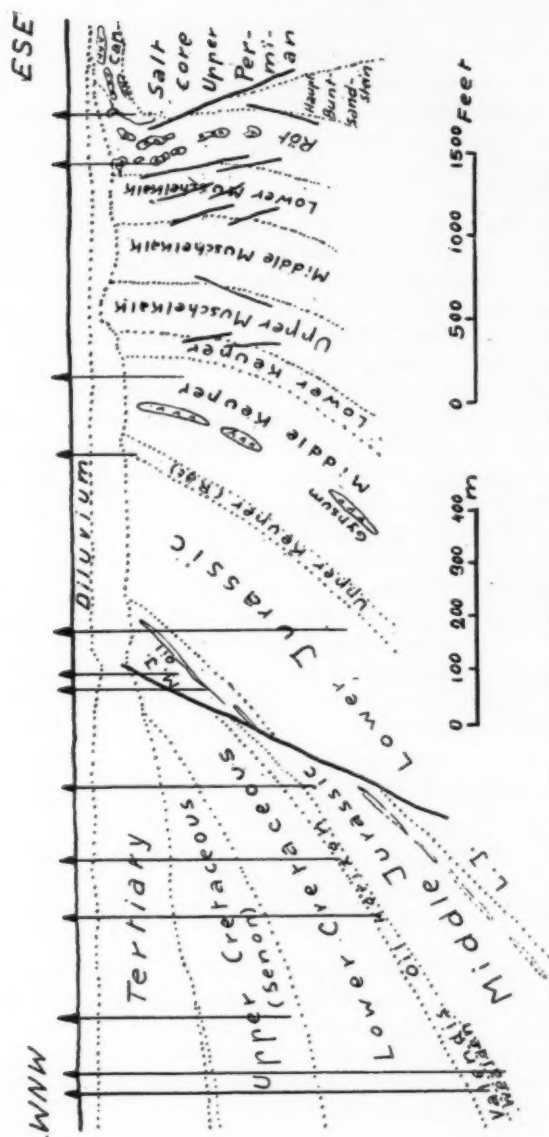


FIG. 6. Section across the west flank of the Håningsen-Nienhagen salt dome and the Nienhagen oil field (after Stoller).

TABLE V  
ANALYSES OF GERMAN OIL-FIELD WATERS

Name of Field	Nienhagen		Nienhagen		Oelheim		Oelheim	
Sample	1		2		3		4	
Ions	Mg. per Liter	Re- action Values in Per- centages	Mg. per Liter	Re- action Values in Per- centages	Mg. per Liter	Re- action Values in Per- centages	Mg. per Liter	Re- action Values in Per- centages
SO <sub>4</sub> .....	20	0.098	...	...	...	...	640	0.163
Cl.....	7500	49.90	16740	50.00	54504.0	49.90	144200	49.80
Br.....	trace	...	...	...	85.0	0.034	300	0.046
J.....	...	...	...	...	3.1	0.0008	...	...
NO <sub>3</sub> .....	...	...	...	...	...	...	...	...
HS.....	...	...	...	...	...	...	...	...
HCO <sub>3</sub> .....	...	...	...	...	112.4	0.0599	...	...
Na.....	3872	38.80	8978	41.30	32148.0	45.10	90880	42.20
K.....	420	2.25	1	0.002	129.5	0.107	2300	0.628
Mg.....	420	8.95	1000	8.73	515.2	1.37	7640	6.70
Ca.....	8	0.09	trace	...	1878.8	3.35	600	0.51
Sum of dissolved substance in gr. per liter...	12.195		28.161		95.5		253.00	
Specific gravity at 17° C.....	1.0101		1.0209		1.0663		1.156	
Primary salinity	82.00		82.60		90.40		85.60	
Secondary salin- ity.....	18.00		17.40		9.48		14.40	
Primary alkalini- ty.....	.....		.....		.....		.....	
Secondary alkali- nity.....	.....		.....		0.12		.....	
Class in the sys- tem of Palmer	4		4		3		4	

This light oil has a specific gravity of 0.85 and contains 20 per cent of gasoline. Salt water does not occur in this field. The rise of the temperature in the wells is 1° C. for only 53 to 60 feet (16 to 18 meters).

Exploitation of the Dogger horizon was begun in 1919. Since that time about 80 wells have been completed within an area of 49 acres (20 hectares) with an average depth of 850 feet (260 meters). The initial

productions of these wells range from 37.5 to 150 barrels (5 to 20 tons) per well per day (Table III).

#### OIL FIELD OF OELHEIM

This oil field is also in the immediate vicinity of a salt dome. Formerly it yielded considerable quantities of oil from strata of the Lower Cretaceous and the Jurassic. The exploited area is only 39 acres (16

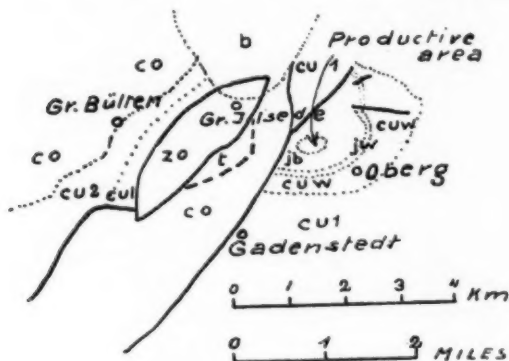


FIG. 7. Sketch map of the Oberg salt dome and oil field (after Georg Beck): zo, salt series of the Upper Permian; t, Triassic; jb, Middle Jurassic; jw, Upper Jurassic; cuw, Lowest Cretaceous (Wealden chiefly); cu1 and cu2, Lower Cretaceous; co, Upper Cretaceous; b, Tertiary. Black lines, faults; dotted lines, formation boundaries.

hectares) in extent. In this district the first flowing well in Germany was drilled in 1880, and it is in this territory that the German oil industry has its origin. For many years the production has been very small and the greater part of the field is flooded by water. As has been shown by the writer in another paper (14) this has been caused by the wells being operated with insufficient technical equipment and without shutting off the water. The oil was of medium heavy quality.

Other occurrences and indications of oil and natural gas in the North German oil province are as yet of no importance.

#### ORIGIN OF OIL IN THE NORTH GERMAN OIL PROVINCE

Several theories have been proposed to explain the origin of oil in northwestern Germany. In the course of the years all formations from the Silurian to the Pleistocene have been considered as the source rocks

of the oil in this province. Several writers have the opinion that the coals of the Upper Carboniferous (Pennsylvanian) and the Lower Cretaceous, or the bituminous shales of the Upper Permian (Zechstein) and the Lower Jurassic (Posidonienschiefer) are responsible for the origin of oil. But all these opinions lack plausibility, as the writer has shown in a previous paper (12).

At any rate it is certain that the formation of oil in the North German province took place in several geological ages.

Strata especially favorable for the origin of oil in northwestern Germany are those of the uppermost Triassic and lowest Jurassic, of the uppermost Jurassic and lowest Cretaceous, and of the Lower Dogger. Oil occurring in the rocks of these periods may be considered to belong to primary deposits, whereas the occurrences in the Pleistocene are doubtless of secondary origin.

Regarding the connection between the formation of oil and the salt domes, two opinions are now expressed, that of J. Stoller (26) and that of the writer (12 and 13).

Stoller thinks that the formation of oil has a direct connection with the formation of the salt domes. He assumes that during the upthrust of salt domes, shallows or banks were formed in the sea where an especially rich organic life would be able to develop and where sandy sediments could be deposited as reservoir rocks. According to Stoller's opinion oil could have been formed at several times but always only in the immediate vicinity of the salt dome. Therefore, the *origin* of oil would be confined to the vicinity of salt domes.

Contrary to this opinion the present writer holds the view that it is impossible to prove that the salt domes have taken any part in the *origin* of oil. He holds that the salt domes are responsible only for the *accumulation* of oil in exploitable deposits. By the upthrust of the salt domes the surrounding strata were inclined and the oil contained in them migrated laterally upward in the same strata and accumulated there. This hypothesis is supported by the occurrence in northern Germany of several oil showings at great distances from the salt domes. Moreover, the flanks of salt domes do not all contain oil, as should be the case if Stoller's hypothesis were correct.

The origin of oil depends, as the writer has shown in detail in another paper (12), on climatic, bionomic, and paleogeographic factors in the area of sedimentation. In many places the origin of oil is related to a change of conditions from marine to saline, brackish- and freshwater, and continental character. Red beds and salt beds may thus be found in connection with the oil reservoir.

This is true in the Upper Triassic and the Upper Jurassic of north-west Germany. There the formation of colored salt-bearing rocks precedes the formation of oil. But these thin salt deposits which are related to the origin of oil have nothing to do with the thick Permian salts forming the salt domes which afford suitable structures for the accumulation of oil.

The origin of oil in northern Germany, as well as in any other part of the world, may be understood only if we consider it as a link in a chain of many different geological events. Very much as in Mesopotamia, Burma, Roumania, and the American Gulf Coast, the North German, the Rhenish, and the Subalpine oil provinces are marked in their geologic history (a) by near-shore, very shallow seas more or less separate from the open sea, (b) by an area of marked subsidence, and (c) by strata of considerable thickness, becoming in their higher parts more and more brackish in character and at last continental. The formation of oil in such an area proceeds under a warm, sometimes arid climate, favoring the formation of salt rocks, and especially at places where marine and brackish-water sediments interchange. Within this oil facies the formation of oil did not necessarily occur once only but could have been repeated several times.

#### OIL LAWS

The laws concerning the prospecting for and the producing of oil are different in the different parts of the North German oil province. In the Prussian provinces of Hanover and Schleswig-Holstein, and in Mecklenburg, oil belongs to the land owner. Anyone who wants to prospect for, or to produce, oil has to sign a contract with the owner of the property. The producer pays the land owner, until the well strikes the oil, an annual compensation of about 1 RM. per 0.62 acre (25 ares), or more, according to the geological prospects of the field concerned. After the oil has been struck the land owner receives a royalty ranging from 5 to 7 per cent of the production besides a small compensation for the derrick location.

In the province of Brandenburg and in parts of the provinces of Saxony and Lower Silesia the right to produce oil belongs to the Prussian State, which has the right to lease the prospecting for, and producing of, oil to third persons. In Brunswick, Oldenburg, Bremen, and Hamburg, the producing right is also reserved to the State and the right of prospecting and producing oil is also leased to third persons.

## METHODS OF PRODUCTION

In Germany two different methods of production are used: drilling and mining.

## DRILLING METHODS

As drilling methods, only water-flush systems are used at present. The cable percussion system is most widely used; the rotary system has been used only once, at Nienhagen.

As the cable percussion system is very much used in Germany, Roumania, Poland, and in other parts of the world, but is practically unknown in the United States of North America, it may be briefly described (Fig. 8).

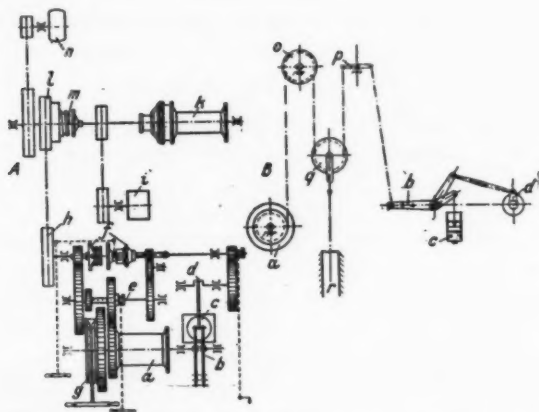


FIG. 8. Cable percussion rig (after Steiner). *A*, ground plan; *B*, side view; *a*, hoisting drum; *b*, walking beam; *c*, cylinder for balancing weight of drilling rods; *d*, crank; *e*, transmission; *f*, clutches; *g*, brake; *h*, belt-pulley; *i*, compressor; *k*, bailing drum; *l*, transmission; *m*, clutch; *n*, motor; *o*, crown pulley; *p*, walking beam; *q*, loose pulley; *r*, well.

The drilling cable is wound on a hoisting drum (*a*) and runs through a pulley (*o*) in the derrick crown over a loose pulley (*q*) which hangs over the drilling hole (*r*) to a walking beam (*p*). On the other end this beam is connected with the walking beam (*b*) of the percussion works proper by a percussion rod. The percussion work is operated by the crank shaft (*d*). A cylinder (*c*) filled with air serves to counterbalance the weight of the drilling poles. The piston rod of the counterbalance

cylinder is connected with the percussion works and serves as a brake when the string is falling. Hence, in drilling, the drilling poles are under tension, the amount of tension depending upon the elasticity of the poles. The tools strike a springing blow, rebounding rapidly.

The percussion work is united with a draw work serving for lowering and raising the drilling tools and the casing. The lowering of the drilling cable is done by feeding the band brake (*g*) of the drum (*a*). By the transmission (*e*) and the clutch (*f*) different speeds for hoisting the tools may be used.

The hollow drilling poles hang by means of a swivel on the loose pulley (*q*). The drilling is done with mud fluid and 60 to 90 percussions per minute with a stroke of 100 to 200 millimeters.

For the number of the working derricks in northern German oil fields and the number of oil-well plunger pumps and bailers and their driving engines, see Table VI.

## OIL PRODUCTION BY MINING

Oil has been mined at Wietze since 1919 after the method had first been tried at Pechelbronn under German management.

TABLE VI .

DRILLING AND OIL PRODUCTION PLANTS IN NORTHERN GERMANY, 1926  
NUMBER AND DRIVING POWER

(1 PS = 0.9863 HP)

Engines	With Steam Power		With Electric Power		With Combustion Motors		Total	
	Number	PS	Number	PS	Number	PS	Number	PS
1. Drilling plants at work, percussion system	15	588	25	1367	11	470	51	2425
Rotation system	5	137	2	35	3	180	10	352
Total . . . . .	20	725	27	1402	14	650	61	2777
2. Oil production plants at work, oil-well plunger pumps	34	26	482	5346	...	...	516	5372
Bailers	4	81	1146	2556	2	100	1152	2737
Total . . . . .	38	107	1628	7902	2	100	1668	8109

The oil shaft of Wietze is 792 feet (240 meters) deep. It had about 158 feet (48 meters) of Pleistocene (sands, gravels, and glacial deposits) and 422 feet (128 meters) of Tertiary (clay with salt water-bearing sand lenses) until it struck the productive strata of the Wealden. The shaft stands in the lowest zone of the oil sands which dip  $45^{\circ}$  N.

The method of mining is similar to the Pechelbronn method described by Bloesch (4). A second shaft has been sunk near the first one for safety reasons. The monthly output in this mine amounts to 16,900 barrels (2,250 tons) of oil. That is about one-half of the monthly output of the Wietze oil field.

#### RHENISH OIL PROVINCE

##### GEOLOGIC CONDITIONS

In this area (Fig. 2) the Triassic and Jurassic were unconformably deposited on strongly folded Paleozoic. At the beginning of the Tertiary the Mesozoic gradually began to subside in the district of the Upper Rhine and formed faults. In the Oligocene this subsidence reached a considerable amount; therefore at this time the sea was able to advance into this area as a tongue-like shallow belt. Presumably the sea advanced from the north as well as from the south. Other writers believe that this belt of the Oligocene sea was connected on the west with the Tertiary sea of the Paris basin.

Within this arm of the sea subsidence and sedimentation were balancing each other for a longer time, for only in this way can be explained the considerable thickness of Tertiary sediments of more than 3,300 feet (1,000 meters). Sometimes the sea advanced and then sediments of shallow-sea water were deposited; sometimes, when the subsidence was growing slower, the continental deposits prevailed and then brackish-water and fresh-water sediments, with the features of salines, were formed.

In the Miocene, the Paleozoic masses of the Vosges and the Black Forest were uplifted and the arm of the sea between them was detached and became dry, so that only fresh-water or continental deposits were formed there.

Thus to-day the Rhine district, which is formed by the Tertiary, appears to have slipped down between the Vosges and the Black Forest, a structure which we call "graben" (trough).

The stratigraphical and facies conditions of the Tertiary in Alsace are shown in Table VII. As will be seen, the sediments found there are of great thickness and saline, marine, brackish-water, and fresh-

	Formation	Lithologic Character	Facies	Average Thickness	
				Feet	Meters
O L I G O C E N E	Kat-tian	Marls and calcareous sandstones	Fresh water	984	300
		Marls with <i>Cyrena</i>	Brackish water	130-200	40-60
		Shales with <i>Meletta</i>	Marine	490-656	150-200
		Marls with <i>Foraminifera</i>	Marine	66	20
		Upper Pechelbronn beds	In the north: chiefly fresh water. In the south: partly lagoon deposits, partly marine and fresh water	656-915	200-280
		Fossiliferous zone	Shallow, shore near sea water	164-230	50-70
		Lower Pechelbronn beds	Marine, brackish- and fresh-water facies alternately	328-393	100-120
		Red key bed	Saline lagoon facies	131-328	40-100
Eocene	Sann- oisian	Dolomitic zone	Alternation of saline, sea-water, and fresh-water facies	670-815	210-250
	Lute-tian	Basal zone	Fresh water	33-66	10-20

water sediments interchange. Some of the salt beds reach a thickness of more than 1,180 feet (360 meters) and contain valuable potash salts. Red rocks are to be found there too, in the same way as in a few horizons of the North German oil province.

#### OIL FIELDS

##### GENERAL OUTLINE

On the left side of the Rhine oil has been found in French territory at the following places from south to north (Fig. 2): Hirzbach near Altkirch, Ohlungen, Schwabweiler, Oberstritten, Biblisheim-Dürrenbach, Pechelbronn, Sulz u. W., Lobsann, and Kleeburg. Of these it is chiefly the district of Pechelbronn which is of commercial value.

On the same side of the Rhine, oil prospects have been discovered on German territory near the Büchelberg in the Bienwald, near Frankweiler, Dürkheim, and Mettenheim north of Worms. On the right side of the Rhine oil was found between Bruchsaal and Ubstadt, near Heidelberg, Weinheim, and Heppenheim.

##### OIL FIELD OF PECHELBRONN

We can form a fuller conception about the conditions in the Rhenish oil province after an examination of the oil field of Pechelbronn. Although this field now belongs to France it may be described briefly as it is well known by its numerous wells and especially by mining works. It is also well known from detailed publications by Gignoux, Hoffmann, and Hoehne (6 and 11).

*Structure.*—At Pechelbronn the Oligocene dips  $2^{\circ}$ - $8^{\circ}$  SE. No salt domes or anticlines are to be found. On the contrary, many faults have been encountered in wells and in galleries. These faults have a displacement of 6 to 600 feet (2 to 200 meters) and strike generally northeast. As oil and gas accumulate in the highest part of the slightly inclined strata which are cut off by faults, one may get the impression that these oil occurrences were connected with faults. Formerly this opinion led to the supposition that oil had migrated along these faults from greater depths. As a matter of fact these faults did not serve for the migration of the oil, but they acted as barriers for the oil migrating laterally upward in the inclined oil-bearing strata. Thus the arrangement of oil occurrences in lines from southwest to northeast may be explained. This arrangement therefore has nothing to do with an oil line caused by an anticline.

*Oil horizons.*—With the exception of the "Rote Leitschicht" (red key bed) oil has been found in all the horizons of the dolomitic zone (Table VII) up to the shales with *Meletta*. The most important oil horizon is that in Upper Pechelbronn strata. There thirteen oil sands are known. They have a thickness of 6 to 13 feet (2 to 4 meters), and a breadth of 660 feet (200 meters), and are of different lengths. The oil sands are cross-bedded and are not equally saturated with oil. They are surrounded by marls free from oil. The oil sands extend northeast and southwest with their limits not fully known.

In the Pechelbronn field both light and heavy oil occur. The heavy oil is chiefly to be found within the area of fresh-water deposits of the Pechelbronn strata and generally in higher horizons. The light oil is confined to the deeper strata.

*Exploitation.*—The development of this field by wells was begun shortly before 1880, whereas production by mining is much older here and can be traced back to the eighteenth century. About 2,000 holes have been drilled. The depths of most of the wells range from 656 to 984 feet (200 to 300 meters). The area of the whole field where exploitation is going on is estimated to be 136 square miles (350 square kilometers).

The oil production by mining which was started under German management in 1917 has been repeatedly described (4); therefore it is not necessary to give a detailed account here. Altogether five shafts have been, or are being, sunk. They have an average depth of 850 feet (260 meters) and exploit the Upper Pechelbronn strata.

In 1921 the continuation of the oil-bearing Tertiary on the left of the Rhine was successfully struck on the right side of the Rhine between Bruchsal and Ubstadt. An oil horizon was found in sandstones with *Meletta* from 730 to 765 feet (224 to 234 meters) over the "Septarienton" (marine clay with lime nodules). The oil is said to have been light. Drilling is still going on there.

That there are oil possibilities farther north in the Rhine valley is made evident by a well near Heidelberg which has been described by Salomon (22). This well repeatedly showed traces of oil besides salt water in Tertiary strata, with all the characteristic features known in oil fields. The other oil prospects situated on German territory have not yielded oil in paying quantities, but owing to the intensive drilling activity more success may be expected.

## OIL LAWS

In Alsace, in Baden, and in Bavaria oil belongs to the State, which is entitled to lease prospecting and producing rights to third persons for a definite period. In Hessen, which also forms part of the Rhenish oil province, the principle of liberty of mining ("Bergbaufreiheit") is in force. This means that oil is considered to be *res nullius*. Prospecting is free to everybody. The government is bound (a) to grant the property of oil within a certain area permanently without any royalty to (b) anybody who has first ascertained the oil, in its natural deposit and (c) who has claimed it in a valid application.

## ORIGIN OF THE OIL IN THE RHENISH OIL PROVINCE

There is no doubt that oil in the Rhenish oil province originated in the rocks in which it is now found. In former times the pre-Tertiary was often considered to be the source of the oil. But this conception is wrong because bituminous traces have never been found in these strata and because, on account of the facies, they cannot be considered as mother rocks. Moreover the Tertiary facies in the Rhine valley trough are very similar to those in other oil fields. Here no sediments of the open sea are found, but these sediments were deposited in detached lagoons or arms where fresh water and sea water prevailed alternately.

## SUBALPINE OIL PROVINCE

## GEOLOGIC CONDITIONS

The geologic conditions of this province are closely related to the origin of the Alps.

The sediments of the Alpine geosyncline, formed in a shallow sea during the Mesozoic, were driven north in huge overthrust masses (rock sheets) at the end of the Cretaceous and especially in the Lower Tertiary. In the sediments of the Upper Cretaceous known as "Flysch" the gradual change from the geosyncline phase to the orogenetic phase of the geosyncline cycle is to be noticed. The orogenetic phase of the Alpine geosyncline reaches its height in the Lower Tertiary where large new thrust-faults of the Alps have their origin.

The sands, gravels, and boulders formed by the weathering of these rock sheets are let down along the north front of the Alpine range in a thickness of more than 3.7 miles (6 kilometers). This waste filling the last remainder of the Alpine geosyncline is called "molasse." The wall of the forming Alpine range shoving from the south filled this trough of molasse sediments more and more with its waste and finally filled

it completely. \*The boundaries of this seat of sedimentation at the end of the Oligocene and the beginning of the Miocene are shown in Figure 3. The oil-bearing sediments of the Subalps are also the result of orogenic movements as is the case with the other oil provinces previously described.

As the Mesozoic rock sheets have been partly driven forward over the Tertiary borderland of the Alps, we find in the southern part of the molasse district an extremely folded structure complicated by thrust faults, whereas in the northern part simple anticlines and synclines prevail.

#### OIL OCCURRENCES

The oil province commences west of the Swiss molasse district. The oil occurrences of the Swiss part have been described in detail by A. Heim and A. Hartmann (10). In this region oil seepages near Geneva, Yverdon, and between Solothurn and Aarau have been mentioned. Exploitation of the oil has not succeeded commercially at all these places, in spite of several wells and though many regular and undisturbed anticlines are found there. The oil is found in the Aquitan, "bunte Molasse" (Upper Oligocene). Here too it is connected with red strata which sometimes contain gypsum beds.

When we follow this oil zone into Germany we find near Tegernsee the only oil showing of Germany within the Subalpine oil province.

The oil occurring here has been known since the fifteenth century. It is found in overturned anticlines in sandstones of the "Flysch" (Upper Cretaceous). Though in the course of years several wells have been drilled in this district, we know very little about the structure on account of its complexity.

This difficulty is caused by our lack of knowledge about the strata below the Flysch. In the opinion of Richter (21) the Flysch has been driven forward over the molasse. He thinks, and it seems very probable, that the oil migrated along the fissures from the molasse into the older Flysch lying above the molasse. This theory is supported by the presence of brines containing iodines in the vicinity, since iodines also occur with the molasse. Other writers suppose that the oil comes from the Eocene (5) or has originated in the Flysch. A satisfactory explanation has not yet been found; the idea, however, that the oil originated in the molasse is more plausible.

The oil itself is light with a paraffine base and a specific gravity ranging from 0.731 to 0.835, with 20 per cent gasoline. The area where

wells have been drilled comprises only about 124 acres (50 hectares). About 30 wells have been sunk to a depth of 3,750 feet (1,145 meters). The output of oil may be seen in Table III.

Farther east the molasse sediments change to another facies which is called "Schlier." The "Schlier" was first recognized by E. Suess as a special facies of "a dying sea." It contains marls, sands, salt clays, rock salt, and gypsum, shows interbedded brackish-water sediments, and changes in its higher parts more and more to brackish-water and fresh-water sediments. Stratigraphically it belongs to the Lower Miocene.

The "Schlier," too, contains oil and natural gas at several places. In German territory may be mentioned, also, the district of Passau where gas is produced although in small quantities.

In the adjoining parts of Austria oil showings are known in the Schlier near Taufkirchen, Leoprechting, Schärding, Witzendorf near St. Pölten, Mühling, Neulengbach, and other places. Natural gas occurs near Fels, Krems, Herzogenburg, Kapellen, Mauer, and Oeding. Furthermore, numerous brines containing iodine are known.

Although none of these occurrences have commercial value at present, there has developed a not unimportant production of oil on Czechoslovakian territory near Eggebell (Göding). If we follow the Subalpine oil province farther east, it is continued by the Subcarpathian oil province, which cannot be discussed in this paper.

#### RESULTS

Of the three German oil provinces the North German province has the greatest area. It comprises more than 62,000 square miles (160,000 square kilometers). It yields 99.9 per cent of the German output and offers the best prospects for the future. Here exists the possibility of discovering new salt domes by geophysical methods. Of about forty salt domes which have been found in northern Germany, only eight or ten have been drilled to the extent of proving or disproving their oil content. Many of these salt domes are known by two or three wells only, which were drilled decades ago in order to discover potash, without taking care to make sure about the occurrence or existence of oil.

The German oil industry of to-day is split on account of lack of capital into small companies which work without any coöperation. If more and deeper wells could be drilled, we could hope to discover new oil fields. The location and operation of these wells

should, however, follow a joint and comprehensive plan which would necessitate the investment of considerable capital which is now difficult to raise in Germany.

The Rhenish and Subalpine oil provinces also offer good prospects at certain places. There, however, test wells are necessary in many places before a noteworthy commercial success can be expected.

#### BIBLIOGRAPHY

1. Donald C. Barton, "The American Salt Dome Problems in the Light of the Roumanian and German Salt Domes," *Bull. Amer. Assoc. Petrol. Geol.*, Vol. 9 (1925), pp. 1226-68.
2. Donald C. Barton, "The Salt Domes of South Texas," *Bull. Amer. Assoc. Petrol. Geol.*, Vol. 9 (1925), pp. 536-80.
3. Donald C. Barton, "The Gulf Coast Oilfields of Southeast Texas and Southwest Louisiana," *Internat. Bergwirtschaft*, Vol. 1, No. 7-8, 9-10 (1925-26), pp. 182-88, 244-53.
4. Edward Bloesch, "Oil Mining," *Bull. Amer. Assoc. Petrol. Geol.*, Vol. 10 (1926), pp. 405-21.
5. H. De Terra, "Zur Erdölfrage im bayerischen Flysch- und Molasse-Gebiet," *Petroleum Zeitsch.*, Vol. 21 (1925), Heft 33, pp. 2057-61.
6. M. Gignoux et C. Hoffmann, "Le bassin pétrolifère de Pechelbronn," *Bull. Service Carte Géologique d'Alsace et de Lorraine*, Vol. 1 (1920), Fascicule 1, Strasbourg.
7. M. J. Goldman, "Petrography of Salt Dome Cap Rock," *Bull. Amer. Assoc. Petrol. Geol.*, Vol. 9 (1925), No. 1, pp. 42-78.
8. C. A. Heiland, "Das Erdgasvorkommen von Neuengamme bei Hamburg im Lichte geologischer und geophysikalischer Forschung," *Zeitschr. h. prakt. Geologie*, Vol. 32 (1924), No. 7, pp. 89-92.
9. C. A. Heiland, "Das Erdgasvorkommen in Neuengamme bei Hamburg im Lichte geologischer und geophysikalischer Forschung," *Geol. Archiv*, May 6, 1924, pp. 207-60.
10. Arnold Heim and Adolf Hartmann, "Untersuchungen über die petroldführende Molasse der Schweiz," *Beitr. Geologie der Schweiz, Geotechnische Serie*, Lieferung 6, Bern, 1919.
11. Erich Hoehne, "Geologische Untersuchungsergebnisse im Erdölgebiet des Unterelsass," *Mitt. Badische Geolog. Landesanstalt*, Vol. 9 (1922), Heft 1.
12. Walter Kauenhowen, "Die Faziesverhältnisse und ihre Beziehungen zur Erdölbildung an der Wende Jura-Kreide in Nordwestdeutschland," *Petroleum Zeitschr.*, Vol. 23 (1927), Heft 31, pp. 1323-46.
13. Walter Kauenhowen, "Ueber den Zusammenhang zwischen Erdöl- und Salzstockbildung in Nordwestdeutschland," *Bericht über die Erdöltagung in Hildesheim*, Hannover, 1927, and *Internat. Zeitschr. f. Bohrtechnik, Erdölbergbau u. Geol.*, Vol. 35 (1927), Heft 21, pp. 187-92.

14. Walter Kauenhowen, *Die Verwässerung von Erdölfeldern, ihre Ursachen und Bekämpfung*, Berlin (Julius Springer ed., 1928).
15. Walter Kauenhowen, "Paleogeographie und Erdölbildung," *Zeitschr. Deutsche Geologische Gesellschaft*, Vol. 80 (1928). (In Vorbereitung.)
16. E. Koch, "Beiträge zur Geologie des Untergrundes von Hamburg und Umgebung," *Mitt. mineral. geolog. Staatsinstitut*, Heft 9 (Hamburg, 1927), mit 4 Karten.
17. Alfred Kraisz, "Geologische Untersuchungen über das Oelgebiet von Wietze in der Lüneburger Heide," *Archiv für Lagerstättenforschung*, Heft 23, Preuss. Geolog. Landesanstalt (Berlin, 1916).
18. Sidney Powers, "Interior Salt Domes of Texas," *Bull. Amer. Assoc. Petrol. Geol.*, Vol. 10 (1926), No. 1, pp. 1-60.
19. Sidney Powers, "Reflected Buried Hills in the Oil Fields of Persia, Egypt, and Mexico," *Bull. Amer. Assoc. Petrol. Geol.*, Vol. 10 (1926), No. 4, pp. 422-42.
20. Sidney Powers, "Crinerville Oil Field, Oklahoma," *Bull. Amer. Assoc. Petrol. Geol.*, Vol. 11 (1927), No. 10, pp. 1067-85.
21. Max Richter, "Zur Frage des Erdöles vom Tegernsee," *Petroleum Zeitschr.*, Vol. 20 (1924), Heft 9, pp. 315-17.
22. Wilhelm Salomon-Calvi, "Die Erbohrung der Heidelberger Radium-, Sol-Therme und ihre geolog. Verhältnisse," *Abh. Heidelberger Akad. der Wissenschaften, math. nat. Klasse*, 14. Abh. (Heidelberg, 1927.)
23. Charles Schuchert, "The Relations of Stratigraphy and Paleogeography to Petroleum Geology," *Bull. Amer. Assoc. Petrol. Geol.*, Vol. 3 (1919), pp. 286-98.
24. Dudley Stamp, "The Geology of the Oil Field of Burma," *Bull. Amer. Assoc. Petrol. Geol.*, Vol. 11 (1927), pp. 557-79.
25. Hans Stille, "The Upthrust of the Salt Masses of Germany," *Bull. Amer. Assoc. Petrol. Geol.*, Vol. 9 (1925), No. 3, pp. 417-41.
26. J. Stoller, "Das Erdölgebiet Haenigsen-Obershagen-Nienhagen in der südlichen Lüneburger Heide," *Archiv für Lagerstättenforschung*, Heft 36, Preuss. Geolog. Landesanstalt (Berlin, 1927).
27. W. A. J. M. van Waterschoot van der Gracht, "The Structure of the Salt Domes of Northwest Europe as Revealed in Salt Mines," *Bull. Amer. Assoc. Petrol. Geol.*, Vol 9 (1925), No. 2, pp. 326-30.



## ORIGIN OF THE FOLDS OF OSAGE COUNTY, OKLAHOMA<sup>1</sup>

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### ABSTRACT

The folds of Osage County, Oklahoma, consist primarily of low domes, shallow basins, terraces, and inverted terraces. Two of the more important theories concerning the origin of these folds are (1) settling over buried hills and (2) horizontal movement along buried fault planes. The chief objections to the first theory are (a) the thickness and character of the sediments, (b) the persistence of the folds through numerous unconformities, and (c) the great number of both domes and basins, and the similarity between them. A vital objection to the second theory is that horizontal movement along buried fault planes would result in folds more elongate than those formed in Osage County. The characteristics of these folds, especially their domal form, experimental results, and theoretical considerations, all indicate that they are primarily the result of compressive forces acting more or less equally in all directions, although other factors may have exerted a modifying influence.

Within Osage County, Oklahoma, there are many folds whose slight elongation and low dip distinguish them from the elongate folds of the Appalachian type. These peculiarities of the folds of Osage County together with their other characteristics suggest that they are primarily the result of forces generated within the area and acting equally, or nearly so, in all directions. However, other forces and influences have also been effective in forming the folds or modifying their shape.

### DESCRIPTION OF THE FOLDS

*Surface structure.*—The strata in Osage County dip westward at an average rate of 30 or 40 feet per mile. This westward dip is interrupted or modified by many inconspicuous folds (domes, basins, terraces, and inverted terraces). Most of the folds, whether closed or not, are essentially equal in all dimensions.

Almost all of Osage County has been geologically mapped and the structure indicated by contour lines on top of key beds.<sup>3</sup> These contours

<sup>1</sup>Part of doctor's thesis, University of Chicago, 1927. During the preparation of this manuscript the writer received many helpful suggestions from Dr. Rollin T. Chamberlin and Mr. Fred B. Plummer. Manuscript received by the editor, January 4, 1928.

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<sup>3</sup>David White *et al.*, "Structure and Oil and Gas Resources of the Osage Reservation, Oklahoma," *U. S. Geol. Survey Bull.* 686.

have been reconstructed so as to represent the structure of the area after it had been tilted east about 30 to 40 feet per mile (just enough to overcome the prevailing westward dip). Not only was the regional dip eliminated but many of the terraces and inverted terraces became domes and basins. These reconstructed contours indicate the divergence from the bedding plane and give a better picture of the effects of compression, differential settling, or irregular deposition as the case may be. The area in which the contours have been so reconstructed is 12 miles wide from north to south and extends across Osage County from east to west. The number of domes in this area was increased approximately 25 per cent and the number of basins approximately 40 per cent. The measurements of the domes and basins used in this discussion are based upon the reconstructed contours of this area.

The following facts indicate that although the domes and basins are of the same general size and form, the domes are somewhat more numerous and slightly larger than the basins.

	Domes	Basins
Area studied.....	522 sq. miles	522 sq. miles
Number.....	151	89
Average height.....	15-20 feet	10-15 feet
Average length.....	0.95 miles	0.72 miles
Average width.....	0.52 miles	0.42 miles
Ratio of average length to average width.....	1.82	1.72

There is a definite tendency toward regularity of form among the structures, especially among the smaller domes. Both domes and basins are more prominently developed in the eastern half of Osage County than in the western half, although the gradation between the two is not uniform.

*Subsurface structure.*—The sedimentary formations of Osage County consist of Permian and Pennsylvanian strata at the surface, which overlie older Paleozoic formations—all resting upon pre-Cambrian granite. Although local unconformities have been found, in general, the various members of the Pennsylvanian and Permian appear to be conformable, one on another; on the other hand, several prominent unconformities occur in the pre-Pennsylvanian formations. The effect of some of these unconformities has been to truncate the folds previously formed, the dip in the formations below the unconformity being steeper than in those above, and this appears to be the normal relation in the field.

In addition to the truncation of the tops of the domes and anticlines, it appears reasonable that at each unconformity erosion would develop

certain irregularities, probably similar to those developed in the present topography, although an earlier or later stage in the erosion cycle might be represented. These irregularities would probably be governed largely

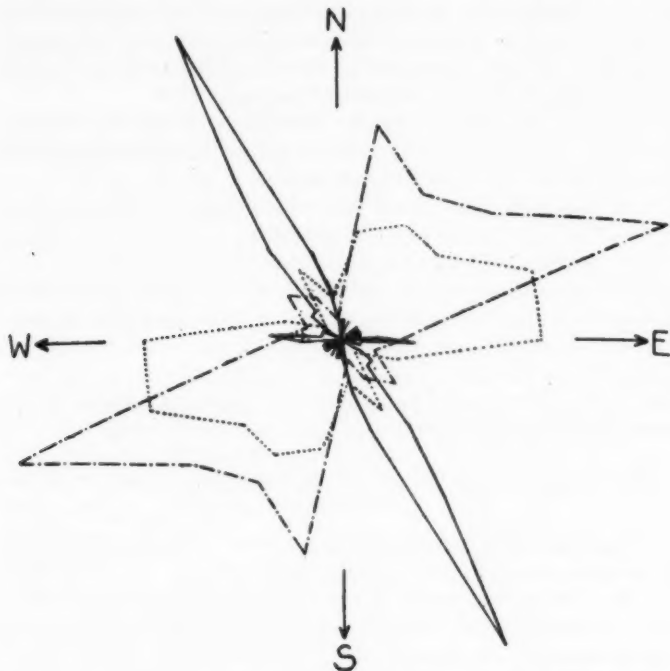


FIG. 1. Diagram showing the strike of the faults (solid line) and the direction of the elongation of the basins (dotted line) and domes (dot-dash line). The faults were classified according to their strike into 36 groups (the strike of each group ranging through an angle of  $5^\circ$ ), and the number of faults in each group plotted. It will be noticed that the prevailing direction of the strike is about  $N. 30^\circ W.$  The domes were similarly classified according to the direction of their elongation into 9 groups, the direction of elongation of the folds in each group having a range of  $20^\circ$ . The sum of the lengths of the short axes was subtracted from the sum of the lengths of the long axes, and the result for each group plotted. The same was done for the basins, but a different scale was used. The average length of the axes of the folds varies little from one direction to the other, but plotting the elongation in various directions, as in the above diagram, greatly accentuates the appearance of elongation.

by the character of the sediments and would be controlled by the granitic surface only where the latter had been uncovered by erosion, which,

so far as can be determined, occurred in comparatively few localities. Very likely, gently sloping areas accompanied by escarpments facing in an opposite direction would be developed. In any case, the topography during each period of erosion would be expressive of the conditions then prevailing and of the formations exposed. The topography would be different for each successive period of erosion and would be controlled by the pre-Cambrian topography only in the comparatively few localities where the granite had been exposed by erosion.

There are not sufficient data to determine accurately the irregularities of the surface of the pre-Cambrian granite, but those irregularities which are the best defined are linear in form.

*Relation of the faults to the folds.*—In addition to the folds, many faults occur in Osage County. These faults strike northwest-southeast and are arranged in linear belts which trend north and south. From Figure 1, it may be observed that there is a close correspondence in the orientation of the domes and basins and that the elongation of both is at right angles to the prevailing direction of the faults. Slight local changes in the direction of the strike of the faults are accompanied by corresponding changes in the elongation of the folds, so that the two are mutually perpendicular.

#### CURRENT HYPOTHESES AS APPLIED TO THE ORIGIN OF THE FOLDS OF OSAGE COUNTY

The following forces might produce folds: (1) intrusion, (2) isostasy, (3) original sedimentation, (4) tension, (5) settling over buried hills, (6) differential compacting of sediments, (7) vertical movement along a fault, (8) horizontal movement along a vertical shear plane, and (9) compression from two opposing directions.

*Intrusion.*—The intrusion of igneous magmas or salt into sedimentary formations may arch the beds, forming laccoliths or salt domes; however, they are much larger and more pronounced structures than those found in this area. The absence of any known salt beds or any known igneous activity since pre-Cambrian time and the persistence of the folds through unconformities are further objections to the theory of intrusive origin of these folds.

*Isostasy.*—Isostasy probably is effective in the formation of such large structural and topographic forms as mountains or plateaus, but it is doubtful if it would produce such small forms as the folds of Osage County.

*Original sedimentation.*—Can the folds of Osage County be the result of initial dips produced when the sediments were deposited? Our knowledge of the irregularities of the sea bottom is very limited except for the area near the shores where the forms are linear and frequently curving, which does not correspond with the form of the folds under discussion. As the folds persist in depth through thousands of feet of sediment, it is difficult to apply this theory since it requires that conditions of deposition should be so similar over successive surfaces that the loci of greater deposition should remain unchanged in spite of great variations in the character of the sediments.

*Tension.*—Tensional forces have been considered the cause for the faults and folds of northeastern Oklahoma. According to this theory settling of the sediments to the northeast and southwest of Osage and adjoining counties produced tensional faults having a northwest-southeast trend.<sup>1</sup> These faults occur chiefly in the sediments below the Osageo lime, and by the settling of the overlying beds the faults produced the folds. The moderate amount of bending postulated by this theory does not appear competent to produce the existing deformation; the elongation of the folds at right angles to the faults rather than parallel with them does not appear consistent with this theory; and no explanation is given of the arrangement of the faults in the north-south zones.

*Settling over buried hills.*—More or less uniform settling of sediments over a rough erosional surface would impress the irregularities of the surface upon the structure of the overlying beds. In other areas folds may have been formed in this manner, but there are serious objections to the theory of such an origin for the folds under discussion. The chief objections are: (1) the thickness and character of the sediments, (2) the persistence of the folds through the numerous unconformities which are here found, and (3) the form and arrangement of the folds.

Only the pre-Cambrian erosional surface could impress its irregularities upon all of the sedimentary formations, as would be necessary to produce these folds which continue vertically throughout the entire stratigraphic column. The formations immediately overlying the pre-Cambrian surface are largely limestones to which a relatively small, or at best, a moderate degree of compacting has been assigned, thus making it only moderately effective in transferring the irregularities of the pre-Cambrian surface to the overlying formations.

<sup>1</sup>A. W. McCoy, "A Short Sketch of the Paleogeography and Historical Geology of the Mid-Continent Oil District and Its Importance to Petroleum Geology," *Bull. Amer. Assoc. Petrol. Geol.*, Vol. 5 (1921), pp. 579-83.

Consolidation of the sediments begins as soon as they are deposited and for a time the rate of consolidation may increase, due to the additional weight of the newly deposited sediments. But how long will this consolidation continue to be effective? Is it likely that during Permian and Pennsylvanian time this process of consolidation was still going on, in sediments originally deposited in Cambrian and Ordovician time, especially if these sediments consist largely of limestone in which the rate of consolidation is probably rapid? Yet consolidation of the early Paleozoic sediments must have continued throughout all of Paleozoic time, if the compacting of the sediments was to be effective in causing the surface formations to reflect the irregularities of the pre-Cambrian topography.

Several unconformities underlie the surface formations and at these unconformities there are irregularities in the underlying erosional surface. If the folds were the result of compacting, these irregularities would furnish loci about which folds would develop and the folds would then disappear below the unconformity. On the contrary, the folds of Osage County persist vertically through several unconformities.

When it is considered that erosion would probably develop escarpments at the various unconformities and that the best defined irregularities in the pre-Cambrian topography are linear in form, it seems reasonable to expect that compacting of the sediments, if effective, would result in a greater development of linear folds than is found. While granitic peaks may exist in Osage County, it is far from proved that they occur below every dome as is required by the compacting theory. Basins are nearly as common as domes. It is conceivable that the basins might develop by compacting over limestone sinks but their arrangement and form (as will be discussed later) suggest an origin very much the same as for the domes.

*Differential compacting of sediments.*—All sediments undergo more or less compacting, the amount depending in part upon the character of the sediments. For example, sandstone and limestone presumably do not decrease as much in volume as shale. If sediments capable of great compacting were deposited in certain areas, those capable of but slight compacting in other areas, and those capable of an intermediate amount of compacting in the intervening areas, and if these sites of deposition of the various types of sediments remained unchanged throughout all Paleozoic time, then, and only then, would it be possible to develop by differential compacting the domes and basins of Osage County which persist throughout the entire geological column. The

foregoing requirements of the theory (differential compacting) are sufficient to discredit it as the cause of these folds. Moreover, the sites of deposition of the distinctive types of deposits would have to be fairly regular in outline, not elongate and curving as are the bars and spits with which we are familiar.

*Vertical movement along a fault.*—Vertical movement along a buried fault plane might produce folds at the surface. However, such folds would be asymmetrical and greatly elongate, which is not the case with those of Osage County.

*Horizontal movement along a vertical shear plane.*—To explain the remarkably uniform orientation of the individual faults in the north Mid-Continent area and their arrangement into several zones, Fath<sup>1</sup> has suggested that the faults are due to horizontal movement along buried vertical shear planes extending north and south, the area east of the shear zone moving relatively to the north. Could the folds, which are slightly elongate perpendicular to the strike of the faults, also be formed in the same manner?

Shearing along buried fault planes was simulated in the laboratory,<sup>2</sup> forming folds and tension and thrust faults. The axes of the folds and the strike of the thrust faults were parallel to the long axis of the resulting strain ellipsoid and the strike of the tension faults was parallel to the short axis of the strain ellipsoid. The length of the folds produced was three to five times their width, in spite of the fact that they were truncated by normal faults; presumably their length would have been six to ten times their width if they had not been so truncated. Mead's<sup>3</sup> experiments on simple rotational stress resulted in elongate folds ten to twenty times as long as they were wide.

Rotational stress develops compressional forces in only two opposing directions and at right angles to this direction there is no compressive force. The only type of fold indicating considerable shortening in one direction and none at right angles is a fold indefinitely elongated, which consequently should be the type developed by rotational stress. The-

<sup>1</sup>A. E. Fath, "The Origin of the Faults, Anticlines, and Buried 'Granite Ridge' of the Northern Part of the Mid-Continent Oil and Gas Field," *U. S. Geol. Survey Professional Paper* 128-C.

<sup>2</sup>A paper discussing these experiments in more detail will be published later.

<sup>3</sup>"Notes on the Mechanics of Geological Structure," *Jour. of Geol.*, Vol. 28 (1920), pp. 505-23.

oretical considerations and experimental results both indicate that the folds of Osage County with their slight elongation (their length is not twice their width) were not primarily produced by horizontal movement along a buried vertical shear plane, although such movements probably modified their shape, producing the slight elongation.

*Compressional forces acting in opposing directions.*—Could the folds of Osage County have resulted from the transmission of compressional forces originating in the region of the Ozarks or elsewhere? The greater development of the folds in the eastern than in the western part of Osage County is suggestive of the invasion of compressional forces from the east. However, this relation can also be explained by the greater age of the strata on the east and their having been subjected to more periods of deformation. The competency of the upper formations to transmit thrust has been questioned, but the lower formations are competent and might well transmit forces which would be reflected upward into the overlying formations.

If an area is subjected to compressive forces from one direction (or, more strictly speaking, from two opposing directions), the component of force perpendicular to this direction is zero. Hence, there is no tendency to shorten in this direction and folds are formed with their axes perpendicular to the direction of compression. Theoretically, the folds should be indefinitely long; actually, they may be fifteen or more times as long as they are wide, the elongate anticlines of the Appalachian type being good examples. In Mead's<sup>1</sup> experiments on simple compression folds were produced with their length ten to twenty times their width.

Both theoretical considerations and experimental results indicate that folds produced by simple compression from two opposing directions are greatly elongated. If compression were to be applied to these folds parallel to their axes, a second set of equally elongated folds would probably be produced without entirely destroying those previously formed, as has been verified by experimental data and field observations. The slight elongation of the folds of Osage County indicates that they were not formed by compression from two opposing directions.

<sup>1</sup>"Notes on the Mechanics of Geological Structures," *Jour. of Geol.*, Vol. 28 (1920), pp. 505-23.

## PROBABLE ORIGIN OF THE FOLDS OF OSAGE COUNTY

The folds of Osage County are believed to be primarily the result of compressive forces acting from all directions. The evidence in favor of this theory includes the following facts:

(1) The domal form of the folds implies compression from all directions.

(2) Other characteristics of the folds, such as their elongation, localization over granitic highs, their vertical persistence, and the similarity of the domes and basins are consistent with this theory.

(3) Domal folds can be produced experimentally by compression from all directions.

(4) The compressive forces, causing folding in the earth, probably originated as forces acting more or less equally in all horizontal directions, and of sufficient magnitude to produce the folds of Osage County—their characteristics are consistent with an origin from such forces.

*Domal form and compression.*—The domes and basins of Osage County are typically symmetrical and of but slight elongation. Their nearly uniform dip in all directions indicates shortening in all directions, consequently compression from all directions. Such compression might be the result of either (1) two sets of nearly equal forces acting simultaneously and at right angles to each other, or (2) compression from an infinite number of directions acting much like the forces generated by a sheet of rubber which has been stretched in all directions and the tension released.

The production of domal folds from only two independent sets of opposing forces acting simultaneously necessitates a nice balance between these forces, and failure to maintain this balance at any time would result in elongation of folding. Later compression, acting chiefly in the direction of the elongation of the folds, would not be compensating; the best that it could do would merely be to produce new folds elongated in a different direction. Because such a nice balance would have to be continuously maintained between independent forces, it appears more reasonable to believe that the folds of Osage County are the result of an infinite number of forces acting in an infinite number of directions with more or less equal intensity and originating from a common source.

*Elongation of folds.*—As previously stated, the domal form of the folds implies compression in all directions. How can this be reconciled with the tensional forces required to produce the faults? What is the explanation of the elongation of the folds? The simplest answer to these

questions is that two sets of forces were operative — compressional forces acting in all directions and rotational stress developed by horizontal movements above a buried vertical shear plane. The folds are the result of both sets of forces, the compressional forces being the chief agency in their formation and the shearing forces producing the elongation. The amount of deformation of a typical dome resulting from compressional forces has been calculated to be several times the amount due to the shearing forces. The shearing forces alone produced the faults, which probably were formed after the period of maximum intensity of the compressional forces; otherwise, the greater compressional forces probably would have developed some thrust faulting.

*Localization of folds.*<sup>1</sup>—If the folds are not the result of compacting of sediments over an uneven pre-Cambrian erosional surface, then how can one explain the localization of domes over hills in this pre-Cambrian topography? As previously stated, not all of the domes have been proved to overlie granitic highs as required by the compacting theory. Moreover, the theories of compression and of compacting are not mutually exclusive. The consolidation of the sediments might well develop dips sloping away on all sides from a pre-Cambrian hill and such dips might well localize folding when compression was applied. Furthermore, compression, acting alone, would develop unequal stresses over granitic peaks, and such stresses, without the aid of dips developed by compacting, might localize folds.

The basins and such domes as are not located over hills in the pre-Cambrian granite might be localized by such factors as initial dips, irregularities developed by differential settling of the beds, and local differences in the physical properties of the beds.

*Vertical persistence of folds.*—If the folds are primarily the result of compression, then any folds formed at an early period may serve to localize folds formed during a later period of compression. It is only through the influence of compression that irregularities (originally developed by differential compacting or settling over buried hills or in any other manner) can persist through thousands of feet of sediments and be effectively reflected at the surface, as is the case in Osage County.

*Relationship of domes to basins.*—Although the domes are slightly more regular, more numerous, and larger than the basins, still the resemblance between the two in size, shape, orientation, and distribution is so great as to strongly suggest a similar origin.

<sup>1</sup>A paper will be published later concerning certain experiments relating to the effect of many of the factors here discussed on the localization of folds.

The basins and domes are so plentiful in certain areas that their failure to overlap each other, with consequent interference in form, requires explanation. It has been calculated that 40 per cent of the basins in some areas, as T. 24 and 25 N., R. 9 E., would overlap the domes if the two were localized by independent causes. Within the given area there are 23 basins and none of them overlap the domes. Similar relations exist in other areas. The mutual exclusion of domes and basins from the same area is readily explained if they were both formed by compression.

As previously stated, there are some slight differences between the domes and the basins. The fact that the domes are larger and more numerous than the basins may be attributed to the greater ease of bending upward against which the force of gravity offers the chief resistance as compared with bending downwards which is resisted by the presence of the strata which must either be compressed or forced out of the way.

*Experimental data.*—Folds of a domal form having slight but nearly equal dips in all directions and closely simulating those of Osage County have been formed (under proper conditions) by the application of forces which produced compression from all directions. Folds of irregular form have been produced in paper and other thin bodies in the above manner and folds of regular form have been similarly produced in linoleum and heavy sheets of rubber. For the production of regular domes a nice adjustment of the forces acting at right angles to each other is required; otherwise, elongate folds are formed.

*Some principles of earth dynamics.*—Because of their conspicuous character and early study, the dynamics of the Appalachian type of folds have been so thoroughly impressed upon our minds that when one thinks of compressive forces, he almost invariably first thinks of forces acting in only two opposing directions, rather than of forces acting inward from all directions. But what is the fundamental cause of folding? The compression causing the folds has generally been ascribed to shrinkage of the earth resulting from cooling, molecular rearrangement, or other factors, all of which act more or less equally in all directions unless modified by secondary factors such as the crowding of ocean basins against continental segments. This crowding results in elongate folds with relatively high dips. The stresses from a large area are concentrated in a much smaller one and act primarily from two opposing directions. However, it appears reasonable that, at least

locally, the original compressive forces would not be modified by secondary factors and that folds should be formed by compressive forces generated locally and acting more or less equally in all directions. Such folds would be characterized by low dips, as the amount of compression developed locally would not be sufficient to develop steep ones. The folds would also be characterized by domal form because the forces are nearly equal in all directions. In general, the development of such folds would not be associated with the development of the folds of the Appalachian type. Either the two would occur in distinct areas or the two would be formed at different times; but in no case would one expect a gradation between the two types. The Appalachian type of folds should occur and do occur primarily along the continental margins; the low domal type, such as those of Osage County, occur primarily in the interior of the continents.

*Amount of deformation.*—Assuming that all of the shortening and shearing result in deformation, the amount of each necessary to produce a dome of average dimensions (height 18 feet, length 0.95 miles, width 0.53 miles) is (1) a few inches of shortening per linear mile, (2) for each linear mile between shear planes, a few inches of movement along the individual shear planes.

These amounts might require some reduction when applied to Osage County as a whole, rather than merely to the folds of the county, as much of the area is not folded; however, this may be more than compensated by the fact that much of the movement does not result in deformation. The above amounts of shearing and shortening have occurred since Permian or Pennsylvanian time and it has been estimated that, since then, the amount of crustal shortening averages 20 feet or more a mile. Even if this estimate should prove to be excessive, quite apparently the forces generated locally are of sufficient magnitude to form low domes such as those of Osage County, but probably not any having dips in excess of five or ten degrees.

#### CONCLUSIONS

1. The folds of Osage County are primarily the result of compressional forces acting with nearly equal intensity in all horizontal directions and probably developed locally.

2. Certain modifying factors, while not essential to the development of the folds of Osage County nor adequate to produce them, may have exerted considerable influence; as (1) shearing movements pro-

ducing the elongation and orientation and (2) differential compacting and settling over buried hills localizing the folds.

3. Slight dip and nearly equal dimensions in all horizontal directions are essential characteristics of the folds of the Osage type.



## CONSEQUENT STREAMS<sup>1</sup>

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### ABSTRACT

In a region such as the coastal belt of southern California where alluvial plains have been deformed in the latter part of the Pleistocene epoch, the pattern of the consequent streams may be used as a means of determining the positions of some of the underlying geological structures. It is particularly useful in the detection of anticlines. Under favorable conditions the stream pattern is a more accurate means of determining the structure than is the warping of the Pleistocene or Dominguez land surface. Apparently, at the opening of an epoch of deformation the initial warping of the land surface is more closely related to the underlying structure than is the later deformation. Streams entrench themselves as the initial uplift occurs and maintain their pattern by down-cutting throughout later deformation. It is this characteristic of consequent streams which makes them so useful to the structural geologist.

If a sloping area is anticlinally warped the streams on the lower side will be quickened and those on the higher side will not develop at all, or, if they do, the divide will be shifted toward the higher land.

In case an erosion cycle is interrupted by deformation the remnants of the topography and the consequent stream pattern will persist into the later cycle with more or less modification.

Streams whose channels are established in harmony with the initial slope of the land are said to be consequent. Streams of this class may be divided into two divergent groups on the basis of the origin of the surface on which they flow. In one group streams establish their courses on newly exposed land surfaces. Lava crusts, fault scarps, and the bottoms of lakes and seas after the lakes or seas have retreated are examples of this group of surfaces. These consequent streams are of slight importance to the structural geologist. The other group of streams form their channels on tilted plains. The pattern of these streams bears a significant relationship to the deformation of the land surface. The plains may have been formed by erosional or depositional processes or a combination of both. Although a knowledge of consequent streams on each type of plain is necessary, those on depositional surfaces are more important to the structural geologist who is working in the Los Angeles coastal belt.

<sup>1</sup>Paper received by the editor, February 14, 1928.

<sup>2</sup>Chief geologist, Miley Oil Company.

## PLAINS OF DENUDATION

Plains of denudation are the result of the long-continued action of streams and other agents of erosion on land surfaces. As the highlands are removed a plain is approached. These plains are the result of destructional processes. The plain has been called a peneplain by W. M. Davis.<sup>1</sup> Such a surface is not a perfect plain in a geometrical sense. Along the ocean shores it forms at sea-level. Inland at the drainage divides it is necessarily higher. Even where the plain is practically perfect, hard rock masses will rise above it as hills. These are termed monadnocks. It has been estimated that more than fifteen million years will be required to reduce North America to such a plain. This estimate is probably low. The time which elapses between the initial uplift of the land and the completion of a peneplain is termed an erosion cycle. Plains of less extent than a continental peneplain may develop in shorter time under favorable circumstances. Proximity to the sea and softness of rock permit the rapid production of such a plain. During the progress of erosion, streams may develop from the original drainage system along the more easily eroded rocks. These streams are called "subsequent." Their pattern is essentially different from either consequent or antecedent streams. As the peneplain is approached the streams broaden out their valleys and meander widely. They may even be released entirely from the guidance of the conditions which originally controlled their courses.

In a region of frequent deformations such as the western part of the United States the surface of the earth is generally warped or uplifted before there is time for the completion of a peneplain. In this case the erosion cycle is interrupted, a new cycle commences, and the streams are revived. As a result we find uplifted remnants of former surfaces which vary in their characteristics from those of an initially uplifted land mass to those of a peneplain. In case an erosion cycle has been interrupted various types of erosion patterns will persist into the following erosion cycle.

## PLAINS OF DEPOSITION

Plains of deposition are formed when streams or other agents of transportation are unable to carry their loads. The plains are constructional in origin. This condition occurs when the velocity of a stream is checked either by reduction in grade or by the diminution of

<sup>1</sup>W. M. Davis, "Topographic Development of the Triassic Formation of the Connecticut Valley," *Amer. Jour. Sci.*, 3rd Ser., Vol. 37 (1889), p. 430.

volume. The surfaces of deltas, alluvial fans and valley fills are plains of deposition. These plains may be divided into two classes on the basis of the previous history of the area. In the case of a delta built into a sea there need be no deformation of the surface of the earth except isostatic adjustment. The delta simply replaces sea water. In a region of complex deformation we find a second type. In this case elevated and depressed areas are formed in close proximity. Great quantities of detritus are obtained by the streams in the elevated areas. Generally the streams can not carry their loads across the depressions and consequently alluvial fans and valley fills are formed. In some cases depressions are occupied by lakes, brackish lagoons, or marine waters. Under these circumstances, the streams fill up the depression by building deltas into the water-filled valleys. In arid regions the wind aids in modelling the surface of the land by sweeping the dust and sand away from beaches, stream banks and alluvial fans and depositing it as dune-sand or in thin sheets among the plants on the floors of valleys. In moist regions the flood waters deposit mud in the depressions. The depositional surface, therefore, may be formed by terrestrial, aeolian, lagunal, and marine sediments.

#### STRUCTURAL DEFORMATION OF PLAINS

In a region where epochs of structural deformation alternate with those of quiet, anticlinal uplifts may be covered by alluvium. After a period of quiet the strains accumulate until the crust is deformed. The weaker structures yield first. These are anticlines and faults. The easiest direction of relief is upward because the air offers less resistance than do the rocks which lie in other directions. At the surface the upward movement is registered by a warping of the alluvium.

As the stresses increase in intensity, particularly in the underlying more consolidated rocks, movements of translation, overturning, and even thrusting develop. These movements warp the land surface in a more complicated manner. Variations in the direction of stresses may occur. When horizontal motion occurs on nearly vertical faults as a result of stresses which are applied obliquely to the fault plane the component of stress parallel to the fault is relieved and that at right angles modifies the direction of the original stress. This is shown by the direction of the axes of folds near our major fault lines. The modification of the direction of stress is probably responsible for the difference between the direction of the axis of folding and the direction of the axis of the anticlinally warped land surface which has been shown in many of our

oil fields. The increase in intensity and the modification of the direction of the forces may shift the positions of the topographic highs during the process of deformation.

#### PLAINS OF THE LOS ANGELES COASTAL BELT

Three plains have been formed in the Los Angeles coastal region. The earliest of these, the Cahuenga, is known only in the mountains. The development of the second of these, the Dominguez surface, was terminated by deformation in the latter part of the Pleistocene period, and the third is in the process of formation at the present time. The latter plains have been formed for the most part by depositional processes. Each is, however, in part erosional. When the development of the Dominguez surface was terminated, erosion had failed to remove Signal Hill, Montebello, and Coyote Hills, whose tops may represent the Cahuenga surface.

Post-Dominguez diastrophic forces warped the land surface into uplifts and depressions, and as a result fault scarps and anticlinally and synclinally warped land surfaces were formed. Remnants of erosion such as Signal Hill were raised in the formation of the anticlinal uplifts, the streams eroded the uplifted areas and filled the depressed areas with the sediments. The surface of these deposits is the modern constructional surface. Portions of the uplifted areas, as for instance at Seal Beach and between Huntington Beach and Bolsa Chica, have been reduced to a plain by erosion.

#### FLOOD WATERS

When torrential rains flood the alluvial flats in the Los Angeles coastal belt the water lies on the ground for days. Some of it moves sluggishly toward the river channels, some of it sinks into the alluvium, and some of it evaporates. If, however, diastrophic forces should warp the plain the waters would move down the slopes to the depressions. At first the water would drift through the grass. The flow would be more rapid in the deeper parts. Eventually, channels would form in which the flood waters would collect. These channels are consequent because their pattern is controlled by the acquired slope of the land.

The form of the initial warping of the land determines the pattern of the consequent streams. As long as streams flow rapidly enough they move the sand and pebbles along their channels and cut downward, a process which enables antecedent streams to maintain their channels despite uplifts across their courses, and it also enables consequent

streams to maintain the courses which they established at the onset of the deformation of the land surface despite the variations in warping as diastrophism becomes more intense. The consequent stream pattern preserves the record of the initial warping, and this in its turn corresponds to the structure beneath. The consequent streams radiate away from the domed part of the anticlinal fields. The relationship between the consequent stream pattern, the warping of the land surface, and the underlying structure is shown at Dominguez Hill and Baldwin Hills.

#### DOMINGUEZ HILL

The best example of the Dominguez surface<sup>1</sup> is at Dominguez Hill.<sup>2</sup> Here the former plain has been warped anticlinally and is practically intact except in the southeast where it has been truncated by the Los Angeles River. This hill affords a splendid opportunity for the study of the effects of warping on a land surface. A comparison of the form of the warped surface and the consequent stream pattern led to the discovery that the streams do not radiate away from the topographic high, but do head on a lower area to the northeast of the physiographic axis (Fig. 1). If the consequent streams are plotted on a map on which the structural contours are drawn it becomes apparent that the streams radiate away from the area directly above the top of the structural dome.

#### BALDWIN HILLS

A more complicated and more remarkable example of the principle occurs in the Baldwin Hills,<sup>3</sup> where the plotting of the structural contours of the Inglewood Hills field has demonstrated an anticline which has been divided into two offset portions by the Inglewood fault (Fig. 2). The importance of the fault was recognized by W. S. W. Kew<sup>4</sup> and the structural contours have been published by E. Huguenin,<sup>5</sup> of the California State Mining Bureau. The western part of the field has been displaced in a northerly and downward direction along the fault line, with respect to the eastern part of the field. The consequent stream pattern corresponds decisively with the underlying structure. The

<sup>1</sup>U. S. Geol. Survey, Compton quadrangle, Los Angeles County, California.

<sup>2</sup>Frederick P. Vickery "The Interpretation of the Physiography of the Los Angeles Coastal Belt," *Bull. Amer. Assoc. Petrol Geol.*, Vol. XI, No. 4 (Apr., 1927), p. 417.

<sup>3</sup>U. S. Geol. Survey, Inglewood and Hollywood quadrangles.

<sup>4</sup>W. S. W. Kew, "Geologic Evidence Bearing on the Inglewood Earthquake of June 21, 1920," *Bull. Seismol. Soc. America*, Vol. 13, No. 4 (Dec., 1923), pp. 156-58.

<sup>5</sup>Huguenin, "Inglewood Oil Field," *Summary of Operations Calif. Oil Fields*, Vol. II, No. 12, San Francisco, California, June, 1926.

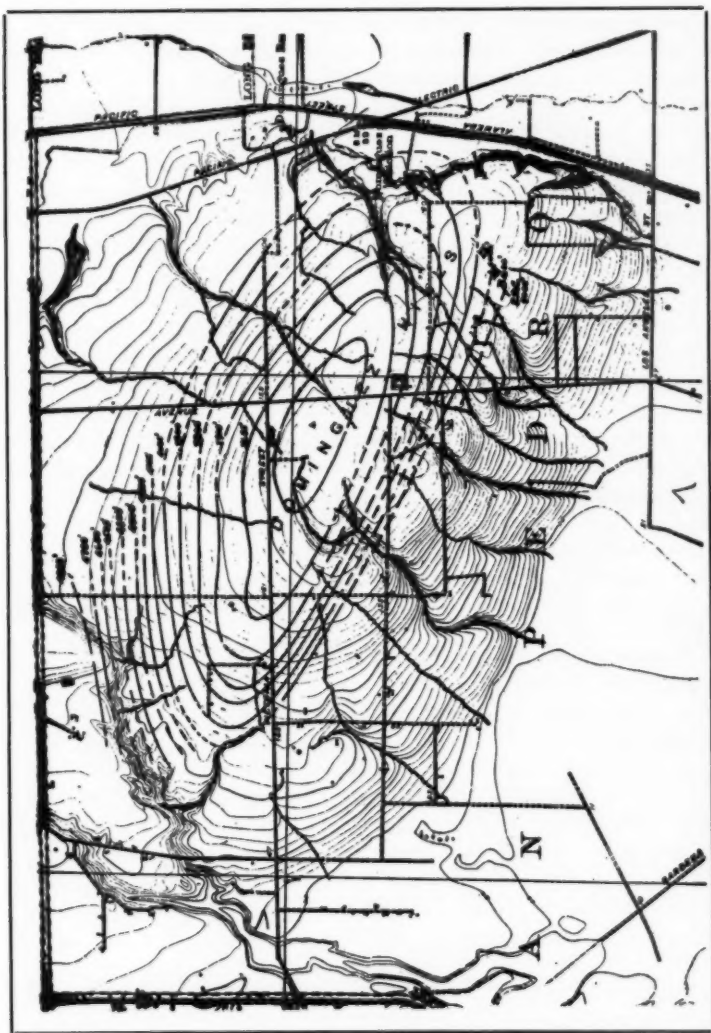


FIG. 1. Dominguez Hill, showing topographic contours (after *U. S. Geol. Survey*, Compton quadrangle), structural contours, and radiating consequent stream pattern. Notice that the streams radiate from an area northeast of the topographic high. Contour intervals: topography, 5 feet; structure, 100 feet.

offset in the axis of the fold is shown. The streams radiate from the divided portions of the elongated dome.

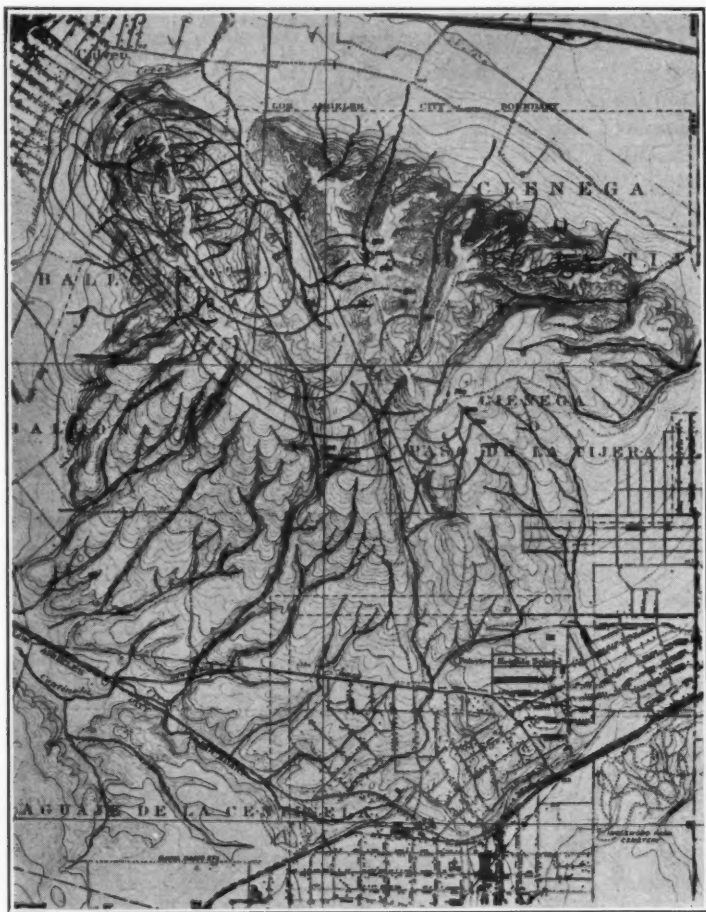


FIG. 2. Inglewood Hills, showing topographic contours (after *U. S. Geol. Survey*, Inglewood and Hollywood quadrangles), structural contours (after E. Huguenin), and radiating consequent stream pattern. Notice the division of the field by the fault. The consequent streams radiate from each of the structural highs. Contour intervals: topography, 5 feet; structure, 100 feet.

## OTHER FIELDS

An analysis of the remaining fields shows that the consequent stream patterns have been destroyed in part by the erosion of modern streams, as in the case of Huntington Beach and Seal Beach, covered by sand dunes, as at Torrence, or modified by the persistence of hills which have remained from the previous erosion cycle, as at Long Beach, Montebello, and the Coyote Hills.

## EFFECT OF THE INITIAL SLOPE OF THE LAND

If the land surface above an anticline has a relatively gentle slope the consequent stream pattern which develops after renewed deformation will be modified. Such a condition occurs when an alluvial fan is built from a mountainous area out across an anticline. When diastrophism becomes active the anticline becomes more closely folded and the land surface above becomes warped. The slope down-stream from the axis of the anticline will be steepened. The streams will be quickened and will develop their basins. On the flank of the anticline toward the hills the consequent streams will not develop until the direction of the slope of the land is reversed. Their development will be hampered by the deposition of sediments between the mountains and the anticline. Until the reversal of the slope occurs the streams on this side of the structure will flow across the axis and augment the streams on the opposite side. The late start and the hindered development of the streams toward the mountains will give the streams on the opposite side a decided advantage. They will maintain their headwaters across the axis of the anticline and the divide will be displaced toward the mountains.

If the deformation is not sufficient to reverse the slope of the alluvial fan no consequent streams can form toward the mountains and the original streams which flowed down the fan will maintain themselves. An intermediate condition may occur in which the major streams are those which originally flowed down the alluvial fan and the minor streams are consequent.

Examples of the extreme conditions are found at Santa Fe Springs and at Richfield.

## SANTA FE SPRINGS

The Santa Fe Springs anticline<sup>1</sup> lies four miles southwest from the Puente Hills. At the opening of the last epoch of deformation there was doubtless a gentle alluvial plain sloping away from the hills (Fig. 3).

<sup>1</sup>U. S. Geol. Survey, Whittier quadrangle.

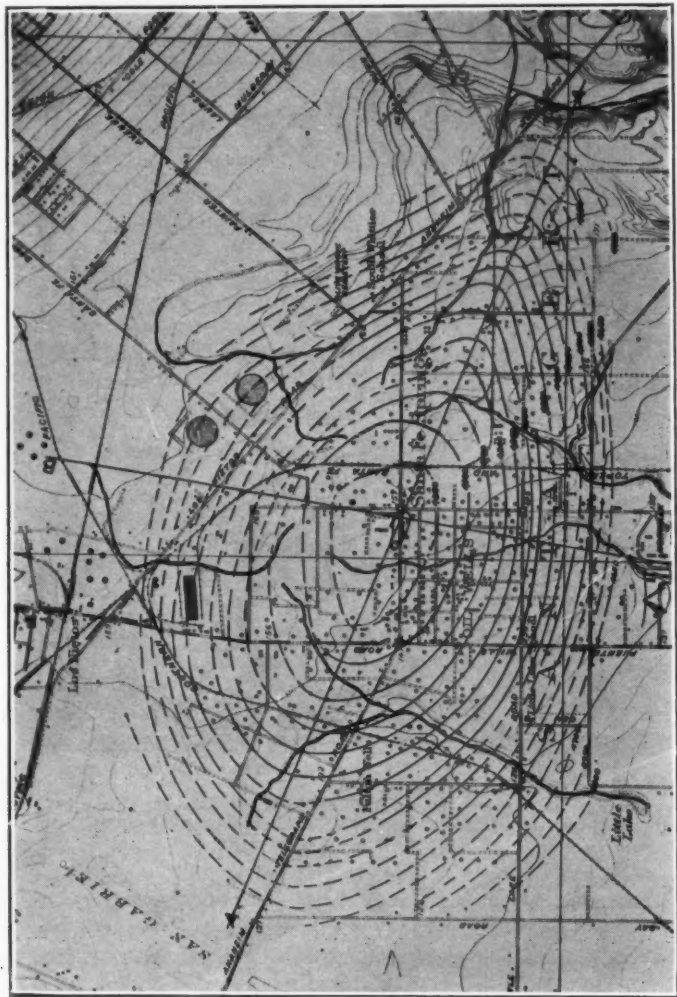


FIG. 3. Santa Fe Springs, showing topographic contours (after U. S. Geol. Survey, Whittier quadrangle), structural contours (after J. B. Case), and the consequent stream pattern. Notice that the stream divide is northeast of the structural axis. The slope of the alluvial surface was from the hills to the northeast. Contour intervals: topography, 5 feet; structure, 50 feet.

A similar slope exists today on the fan of San Gabriel River which flows not far west of the Puente Hills and the Santa Fe Springs field. The alluvial slope from the Puente Hills to-day is doubtless steeper than this

early slope because the hills are higher now than they were at that time. If the structural contours which have been published by J. B. Case of the California State Mining Bureau<sup>1</sup> are drawn on the topographic map it becomes apparent that the divide between the consequent streams lies northeast of the structural axis of the underlying anticline.

#### RICHFIELD

Richfield<sup>2</sup> lies only two and a half miles from the Puente Hills (Fig. 4). Doubtless at the opening of the last epoch of deformation the alluvial

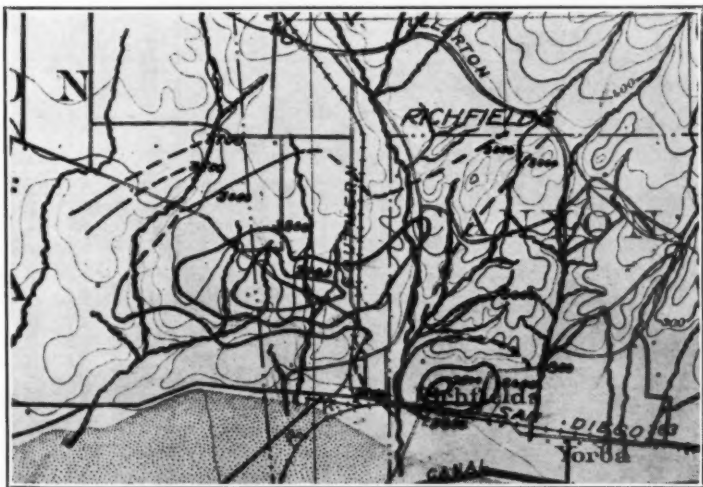


FIG. 4. Richfield, showing topographic contours (after U. S. Geol. Survey, Anaheim quadrangle), structural contours (after W. A. English), and the stream pattern. Notice that the streams cross the structure. Richfield is close to the hills on the northeast.

slopes were steeper than at Santa Fe Springs. The underlying structure has been mapped by W. A. English.<sup>3</sup> When renewed deformation of the anticline occurred, the alluvial slope toward the hills was flattened but

<sup>1</sup>J. B. Case, "Report on Santa Fe Oil Springs Field." *Summary of Operations, California Oil Fields*, Vol. 8, No. 11, 1923.

<sup>2</sup>U. S. Geol. Survey, Anaheim quadrangle.

<sup>3</sup>W. A. English, "The Geology and Oil Resources of the Puente Hills, Southern California," *U. S. Geol. Survey Bull.* 768, 1926.

not reversed in direction. This is shown in the western part of the field. No consequent streams were formed toward the hills. The original streams on the alluvial slope simply maintained themselves as do antecedent streams.

#### REVIVED CONSEQUENTS

In the case of repeated deformations of an anticlinal structure the consequent streams which were formed in an earlier cycle may persist into the present cycle. On the other hand, they may survive with significant modifications. However, they differ so radically from typical antecedents that they are called revived consequent streams. It is difficult to differentiate revived consequent streams from true consequent streams which have developed after renewed deformation on the surface of a peneplaned anticline. The form of the residual hills and the development of subsequent streams are the most satisfactory criteria for the differentiation of the two alternatives. If the conditions have been favorable to the equal development of consequent streams on opposite sides of the anticlinal axis in an earlier cycle, the pattern of the revived consequents should show the position of the anticlinal axis. Examples of topography inherited from an earlier cycle are found in the West Coyote and Montebello fields.

#### WEST COYOTE

The Coyote Hills<sup>1</sup> rise above the level of the Dominguez surface (Fig. 5). Their erosion is much further advanced than is that of the uplifted Dominguez surface. The structure of the hills has been mapped by English.<sup>2</sup> A comparison of the topography and the structure shows that there is a close relationship between the revived consequent stream pattern and the anticlinal axis.

#### MONTEBELLO

At Montebello<sup>3</sup> the divide is slightly north of the structural axis. This relationship may be due to an alluvial slope in an earlier cycle or it may be due to a shifting of divides because the streams on the south are nearer the sea than are those on the north. The relationship between the divide and the structural axis is very close, however. The east end of the hill has been cut away by an antecedent stream.

<sup>1</sup>U. S. Geol. Survey, Anaheim quadrangle.

<sup>2</sup>Loc. cit.

<sup>3</sup>U. S. Geol. Survey, El Monte and Alhambra quadrangles.

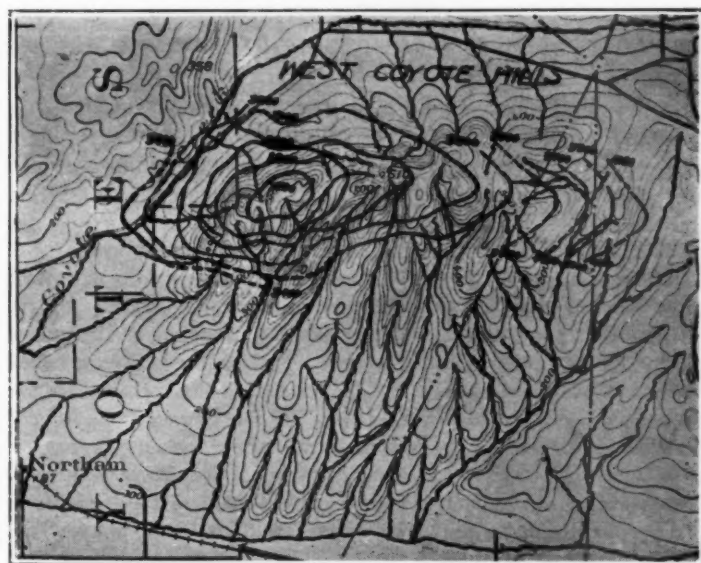


FIG. 5. West Coyote Hills, showing topographic contours (after *U. S. Geol. Survey, Anaheim quadrangle*), structural contours (after W. A. English), and consequent stream pattern. Older hills along the axis rise above the warped Dominguez surface.

#### CONCLUSION

In closing, the writer would point out (1) that a deformed alluvial plain, such as that around Los Angeles, is rarely encountered; (2) that the topographic surface of upwarped areas may be modified by antecedent, subsequent and consequent stream erosion, by marine erosion, and by remnants of earlier cycles; (3) that there is a close relationship between the patterns of radiating consequent streams and underlying anticlinal structures; and (4) that the position of the divide between the consequent streams depends on the original slope of the land.

## RECENTLY DISCOVERED SALT DOMES IN EAST TEXAS<sup>1</sup>

B. COLEMAN RENICK<sup>2</sup>

Palestine, Texas

### ABSTRACT

Prior to 1924 there were six known salt domes in East Texas (Grand Saline, Steen, Brooks, Butler, Keechi, and Palestine domes). In 1924 M. A. Davey discovered the Boggy Creek dome, which promises to yield commercial production. There were discovered in East Texas in 1927, as a result of geological and seismograph work, nine domes (Bethel, Bullard, Oakwood, Whitehouse, East Tyler, Mt. Sylvan, La Rue, Troup, and Haynesville) and perhaps even a tenth (the Salmon prospect), as well as a probable "high" (Cronin structure). The first four mentioned of the discoveries in 1927 are shallow and have since found the salt depths ranging from 500 to 1,500 feet. It is thought that the East Tyler and Mt. Sylvan are also shallow domes. The depth to the salt at the La Rue, Haynesville, and Troup is not yet known, but they are thought to be deeper.

These newly discovered domes are briefly described in this paper which also contains a table showing the Eocene and Upper Cretaceous formations in East Texas. The stratigraphic position and lithologic character of the prospective producing sands are also described. Some theoretical considerations regarding the prospects of commercial production are discussed.

### OLD DOMES

Six salt domes were known in East Texas prior to 1924. These were Grand Saline in Van Zandt County, Steen and Brooks in Smith County, Butler in Freestone County, Keechi and Palestine in Anderson County (Plate 5). Two of these domes, Palestine and Grand Saline, are utilized for commercial salt production and all of them have been prospected to some extent for oil, but so far without success, though a few good showings of oil have been obtained.

The six aforementioned domes were first described by E. T. Dumble<sup>3</sup>

<sup>1</sup>Presented by title before the Association at San Francisco meeting, March 23, 1928.

<sup>2</sup>Consulting geologist.

<sup>3</sup>E. T. Dumble, *Texas Geological Survey, 1st Ann. Rept.*, p. 33; *2nd Ann. Rept.*, (1891), p. LXXVII, Anderson County, pp. 304, 305, 315, 316; Smith County, pp. 206, 209, 224, 316, 323; Freestone County, p. 316; Van Zandt County, pp. 223, 316, 317; *3rd Ann. Rept.*, pp. 46, 76, 77.

and later by O. B. Hopkins,<sup>1</sup> E. De Golyer,<sup>2</sup> Sidney Powers,<sup>3</sup> and C. A. Cheney.<sup>4</sup>

In Powers's paper published in this *Bulletin* in 1926 he brought the information up to date in regard to these known domes. These six known domes are therefore not to be discussed in this paper, but it may be well to mention the fact that in proximity to all of them the rocks are deformed to a considerable extent, the older rocks being brought up to the surface around the periphery of the salt. The depth to the salt in these domes ranges from 120 feet at the Palestine dome to about 400 feet at the Grand Saline dome, though the salt may be somewhat deeper at the Steen dome.

#### ACKNOWLEDGMENTS

Acknowledgments are due to several persons who have kindly furnished helpful information of one sort or another. M. A. Davey of Palestine, Texas, has supplied data especially in regard to the Boggy Creek dome; G. M. Knebel and L. W. MacNaughton, of the Humble Oil and Refining Company, have kindly furnished information regarding the Humble domes in Smith County, and with them the writer has also had profitable discussions in regard to the stratigraphy and other problems. The approximate contact of the Cane River and underlying Carrizo member of the Wilcox formation which is shown on Plate 5, is taken largely from the work of G. M. Knebel and E. A. Wendlandt.

#### BOGGY CREEK OR CAREY LAKE DOME

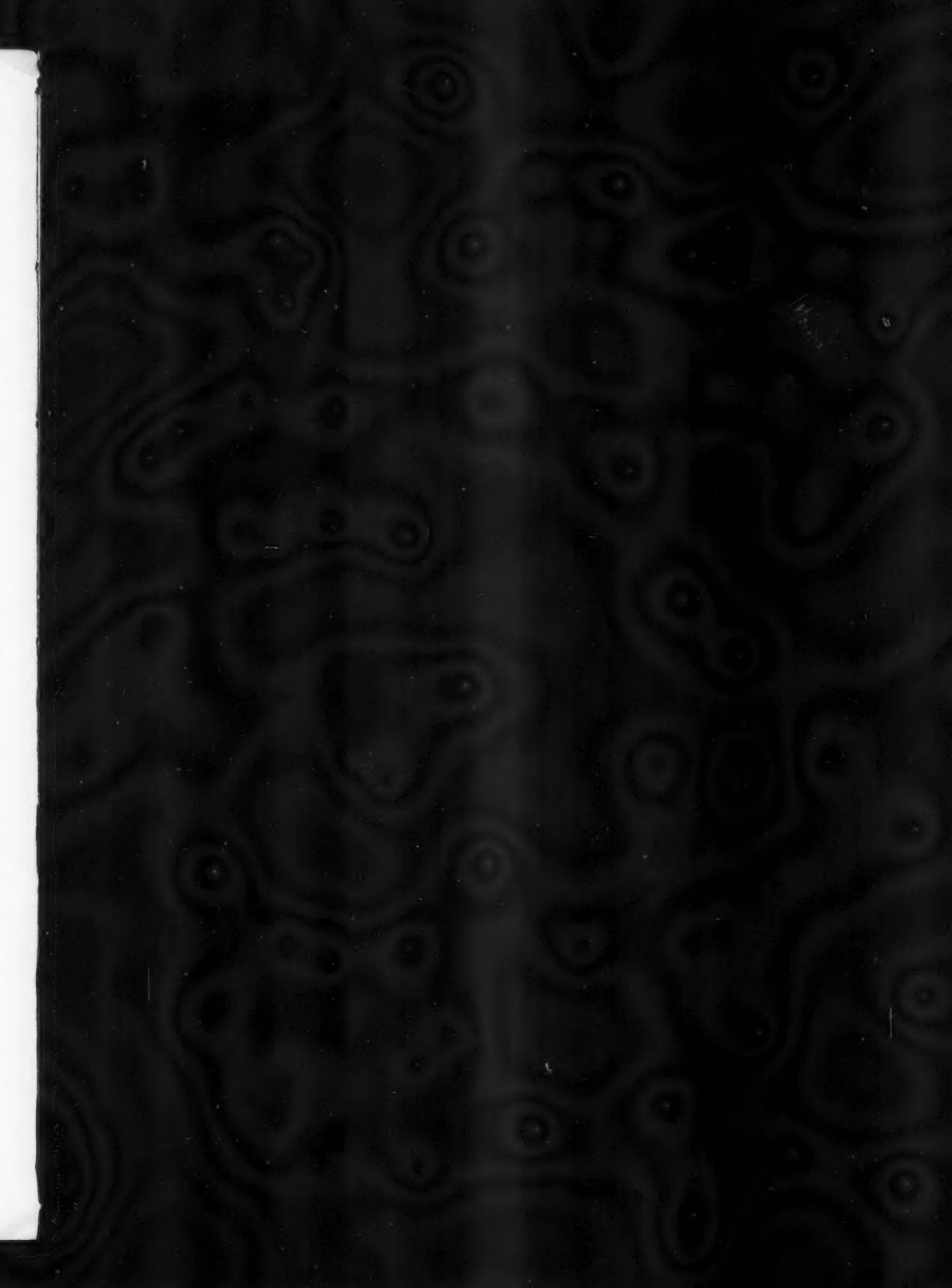
M. A. Davey in the spring of 1924 discovered evidence of an uplift in proximity to Neches River in Anderson and Cherokee counties. The center of this disturbed area is about 14 miles north-northeast of Palestine. After leasing about 8,000 acres here, he drilled a well in this block in the fall of 1924. This well, the Davey, Earl and Ragsdale No. 1, was abandoned in the Pecan Gap chalk at 1,776 feet, thus proving the ex-

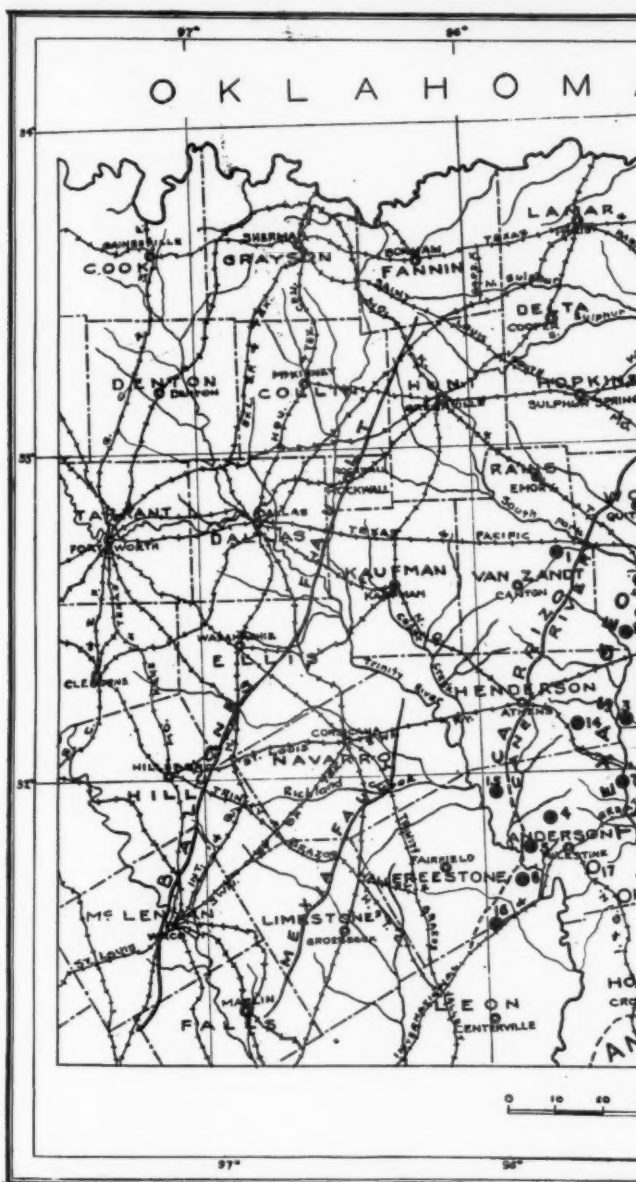
<sup>1</sup>O. B. Hopkins, "The Palestine Salt Dome and Keechi Salt Dome, Anderson County, Texas," *U. S. Geol. Survey Bull.* 661 G, 1917.

<sup>2</sup>E. De Golyer, "The West Point Salt Dome, Freestone County, Texas," *Jour. Geol.*, Vol. 27 (1919), pp. 647-63.

<sup>3</sup>Sidney Powers and O. B. Hopkins, "The Brooks, Steen, and Grand Saline Salt Domes, Smith and Van Zandt Counties, Texas," *U. S. Geol. Survey Bull.* 736 G, 1922. Sidney Powers, "Interior Salt Domes of Texas," *Bull. Amer. Assoc. Petrol. Geol.*, Vol. 10 (1926), pp. 1-60.

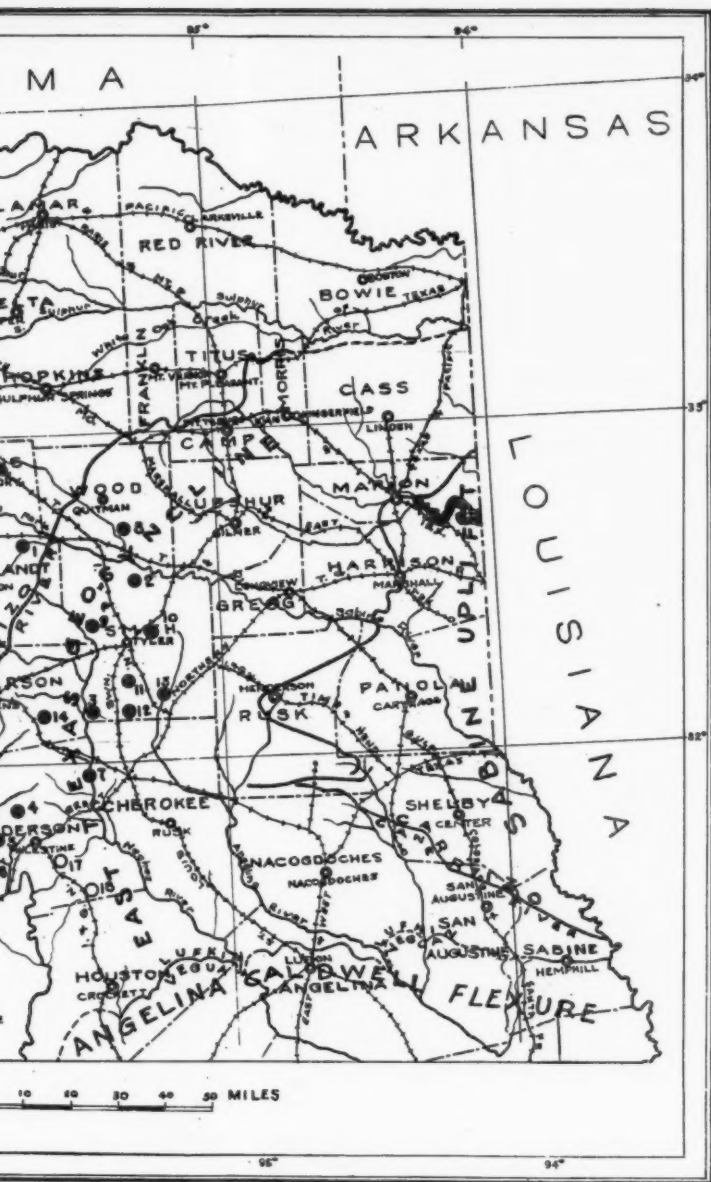
<sup>4</sup>C. A. Cheney, "Salt Domes of Northeastern Texas," *Oil and Gas Jour.*, January 6, 1922, p. 82; reviewed by K. C. Heald, *Bull. Amer. Assoc. Petrol. Geol.*, Vol. 6 (1922), p. 58.





Map showing location of salt domes and related structures in Oklahoma.

No.	Date of Discovery	Name of Dome	Discoverer
1	Prior to 1924	Grand Saline.	.....
2	Prior to 1924	Steen	.....
3	Prior to 1924	Brooks	.....
4	Prior to 1924	Keechi	.....
5	Prior to 1924	Palestine	.....
6	Prior to 1924	Butler	.....
7	1924	Boggy Creek	M. A. Davey
8	1927	Haynesville	Gulf Prod. Co.
9	1927	Mt. Sylvan	Humble O. & R. Co.



Structures in East Texas, by B. Coleman Renick. Drawn by J. F. Wolff, Jr.

Discoverer	No.	Date of Discovery	Name of Dome	Discoverer
.....	10	1927	East Tyler	Humble O. & R. Co.
.....	11	1927	Whitehouse	Humble O. & R. Co.
.....	12	1927	Bullard	Gulf Prod. Co.
.....	13	1927	Troup	Amerada Pet. Co.
.....	14	1927	La Rue	Roxana Pet. Co.
.....	15	1927	Bethel	Pure Oil Co. <sup>9</sup>
.....	16	1927	Sand Lake	Roxana Pet. Co.
.....	17	1927	Cronin Structure	Roxana Pet. Co.
.....	18	1927?	Salmon Structure	.....



istence of a considerable uplift. In the fall of 1924 Mr. Davey, after making a trade with the Humble Oil and Refining Company, commenced drilling core tests on this tract and continued exploration by coring through 1925. Fourteen of these core tests were drilled to the top of the Midway, the depths ranging from 900 to 1,500 feet. In December, 1924, Davey entered into a contract with the Humble Oil and Refining Company whereby he assigned all leases to this company with the exception of a few sold to the Rio Bravo Oil Company. Although the coring operations served to outline this structure, the Humble made an additional check with the seismograph to prove the presence of a salt dome here.

In the spring of 1926 the Humble Company commenced drilling their first well, the Humble's Earl and Ragsdale No. 1, on the east side of the structure in Cherokee County. This well encountered the anhydrite cap at 2,500 feet, and the salt at 2,612 feet; the salt is probably somewhat higher west of this location. The Humble's Templeton No. 1, also in Cherokee County, was the next well drilled, but this well was lost at 3,447 feet in the Lower Cretaceous. The Humble's Elliott and Clark No. 1 was the next well drilled and this proved to be the discovery well. On March 21, 1927, this well found Woodbine sand at 3,842 feet and was drilled 8 feet into the sand. It came in with an estimated yield of 10,000 barrels of oil after being gauged for an hour at several different times. However, owing to lack of storage facilities it was necessary to shut this well in, and when it was finally opened it went to salt water and about 75 barrels of oil per day within a short time. The oil was 38.2° Bé. gravity.

Since the discovery well was drilled, the Humble Oil and Refining Company have drilled twelve more wells, but owing to the general disturbed condition about this dome they have been unfortunate in finding the Woodbine sand pinched out in certain wells, and in others the drill has encountered the salt before striking the Woodbine sand. At the present time the Lizzie Smith No. 1, the fourteenth well drilled, and the sixth one drilled in Anderson County (the remaining eight having been drilled east of Neches River, in Cherokee County), holds forth promise of making a good commercial pumper. At present (February 10, 1928), it is flowing by heads and yielding about 90 barrels a day from about four feet of Woodbine sand at 3,714 feet.

#### SEISMOGRAPH EXPLORATION IN 1927

Following the discovery of oil on the Boggy Creek structure several of the major companies immediately became active in this area. The

Humble Oil and Refining Company, Roxana Petroleum Corporation, Gulf Production Company, Pure Oil Company, and Amerada Petroleum Corporation promptly began looking for additional salt domes in East Texas with the aid of Sun Oil Company seismographs, and the success of this exploration campaign in East Texas is attested by the presence of nine, or possibly ten, newly discovered salt domes, and one presumable "high," all discovered during the spring, summer, and early fall of 1927. Each of these companies had from one to four seismograph parties in the field, each party carrying from two to four instruments.

Several types of seismographs were used. The Geophysical Research Corporation had several parties in the field using the instruments recently devised by them. The seismographs designed by the Bataafsche Petroleum Corporation (Royal Dutch Shell) and the Menthorp seismographs of the Seismos Company of Hanover, Germany, were used successfully. There were also in use several other more or less experimental instruments of American and German design.

It was recognized by the geologists of the major companies operating in this area that the known salt domes in East Texas occurred in the East Texas geosyncline.<sup>1</sup> The geophysical work was therefore concentrated within this syncline, which is between the Sabine uplift on the east and the Mexia and Balcones faults on the west (plate 5). The Cook Mountain and Mount Selman formations of the Claiborne group shown on the accompanying map are at the surface over the central part of the East Texas geosyncline, and all but one of the recently discovered salt domes are within the outcrop of these formations; this exception (Bethel dome) is only a few miles west of the Claiborne outcrop. It is interesting to notice that most of the interior salt domes of Louisiana also occur within the area of the Claiborne outcrop.<sup>2</sup>

The discovery of about two-thirds of these salt domes was due to the recommendation of geologists for seismograph exploration at localities where the surface showed the rocks to be disturbed or where the distribution of surface outcrop was suggestive, or in the vicinity of salines, or near salt springs, or where the topography and drainage suggested the presence of a dome. The remaining salt domes were discovered as a result of random "shooting" as seismograph exploration is termed in the field. The Bethel and Troup domes, and also, the writer under-

<sup>1</sup>Sidney Powers, "Interior Salt Domes of Texas," *Bull. Amer. Assoc. Petrol. Geol.*, Vol. 10 (1926), p. 1.

<sup>2</sup>W. C. Spooner, "Interior Salt Domes of Louisiana," *Bull. Amer. Assoc. Petrol. Geol.*, Vol. 10 (1926), pp. 217-92.

TABLE I  
GENERALIZED TABLE OF EOCENE AND UPPER CRETACEOUS FORMATIONS  
IN EAST TEXAS GEOSYNCLINE

System	Series	Group	Formation	Member	Thickness in Feet	Description
Tertiary	Eocene	Clai-borne	Yegua		900 - 1,000	Sands and clays, generally lignitic; locally contain workable beds of lignite, almost entirely non-marine. Clays and shales, greenish-gray and brownish-gray but weather light and dark gray. Several beds of silicified wood characterize this formation.
				Lufkin*	300 - 400	Marine, chocolate-brown clay containing some fossiliferous beds, some glauconitic beds and thin beds of sand. Upper 5-15 feet generally contains macrofossils, making this member easily recognizable as distinct from the overlying Yegua in core samples. Weathers reddish-brown.
			Cook Mountain	Nacogdoches*	275 - 375	Mostly brown sand, locally containing some glauconite. Some beds of brown clay. Weathers red and tan-gray.
				San Augustine*	15 - 75	Fossiliferous, glauconitic and glauconitic calcareous marl, brown sand and some brown clay, green and greenish-blue when fresh and brownish-red at outcrops.
				Queen City*	150 - 375	Non-fossiliferous, brown, micaceous sand. Some sand beds lignitic; locally beds of lignite. Generally weathers white or light brown. Springs numerous at the outcrop. Member yields considerable water in wells.

TABLE I—Continued

System	Series	Group	Formation	Member	Thickness in Feet	Description
			Mount Selman	Cane River*	5 - 50	Green, glauconitic, micaceous sand and brown clay. In some localities marked by a definite bed of glauconitic clay or sandy clay; in others glauconitic material distributed through interval of 50 feet.
				Carrizo	200 - 300	The upper 200 or 300 feet of Wilcox largely gray and brownish-gray sand but locally contains sandy shale. Carrizo is non-lignitic, which distinguishes it from the Indio. Carrizo generally recognized in well logs.
			Wilcox	Indio (Lignitic Wilcox)	1,450 - 2,150	Gray and brownish-gray sands, clays and shales, both calcareous and non-calcareous. Sands and clays lignitic and locally commercial lignite. Numerous thin beds of hard sandstone and concretionary limestone. Generally the lower 100-200 feet mostly clays and shales and within this or even greater interval near base of Indio are arenaceous <i>Foraminifera</i> , all of which makes it difficult to distinguish Wilcox from Midway either on surface or with well logs and micro-paleontologic data. Indio thinnest along Neches River near center of geosyncline, 1,450-1,550 feet. Thickens eastward and in northwest Angelina County, at least 2,100 feet. Westward in central Freestone County, 2,150 feet. Also thickens southward into Houston County.
			Unconformity?			

TABLE I—Continued

System	Series	Group	Formation	Member	Thickness in Feet	Description
—	Unconformity?		Midway		700 - 1,200	Dark and light gray, bluish-gray and brownish-gray clays and shales with lenses of fine sands, mostly marine. Also thin beds of hard micaceous sandstone and thin lime-concretionary beds. Thickest in southern Anderson and southern Cherokee counties near center of geosyncline.
			Navarro (including Nacatoch sand)		375 - 1,000	Dark and light gray and bluish-gray marine shale and clay, generally slightly calcareous with thin beds of gray limestone and brownish, ferruginous limestone. Some lime beds contain siderite concretions. About 1,000 feet thick in central Freestone County but thins eastward to 400 feet or less in eastern Cherokee County. Near top in eastern Anderson and Cherokee counties, but apparently somewhat higher in the Navarro section in Freestone County where this formation is thicker there is a horizon possibly equivalent to the Nacatoch sand of Louisiana. This Nacatoch(?) horizon in some places is sandy shale, sand and thin non-calcareous sandstone; in others, interbedded thin limestone and shale.
				Pecan Gap chalk	240 - 475	Hard gray chalk, some beds clayey with interbedded calcareous shale. Local pyrite lenses. Fossiliferous and non-fossiliferous varieties. Thickens eastward across geosyncline.

TABLE I—Continued

System	Series	Group	Formation	Member	Thickness in Feet	Description
Cretaceous	Upper Cretaceous		Taylor	Wolfe City sand	60 - 150	Greenish-gray, calcareous, glauconitic sand and hard gray calcareous sandstone with interbedded bluish-gray and greenish-gray shale. Locally absent but where present generally occurs just below Pecan Gap, but in some places there is interval of 10-100 feet gray shale between Wolfe City and overlying chalk.
				Lower Taylor	325 - 500	Mostly hard gray calcareous clays and shales and gray micaceous sandy shales. Also contains greenish-gray, fine, micaceous, glauconitic sands and sandstones.
			Austin chalk		110 - 350+	Hard gray fossiliferous and non-fossiliferous chalk with thin beds calcareous shale and thin streaks pyrite. Thins eastward.
			Unconformity?			
			Eagle Ford shale		0 - 450+	Dark gray, brownish-gray, bluish-gray, olive brown and dark red, non-calcareous clay, slightly micaceous and glauconitic. Generally fossiliferous. Contains some fossiliferous limestone. Fish teeth characteristic.
			Woodbine sand		45 - 540	Light gray, slightly calcareous and non-calcareous medium- to fine-textured sandstone. Also greenish-gray, brownish-gray and tan sand and sandstone. Interbedded hard clay, some with reddish and greenish tint, locally referred to as "Red-beds." Interbedded with the sand are also gray shale and sandy shale.
			Unconformity?			
	Lower Cretaceous					

\*The Lower Claiborne (Cook Mountain and Mount Selman formations), is commonly referred to as the marine Claiborne. The stratigraphic relations of the several members of the Cook Mountain and Mount Selman formations were first worked out in Texas by G. M. Knebel and Miss Alva Ellisor and their associates in the geological department of the Humble Oil and Refining Company. Mr. Knebel studied the stratigraphic succession in the field and Miss Ellisor studied the micro-faunas. The names assigned by them to the several members of the Lower Claiborne (Lufkin, Nacogdoches, San Augustine, Queen City, and Cane River) are now used by many field geologists working in East Texas. The term Lufkin was introduced by Mr. Knebel and Miss Ellisor, but the other terms have been used in the literature previously, though they were not then defined as accurately as they have been recently by the work of the aforementioned geologists.

stands, the Haynesville dome, show little evidence of a dome on the surface. The other new domes show dips around them, though the amount of some of the dips is slight. Not all of these dips are quaquaversal as the symmetrical arrangement may be interrupted by faulting. In these localities where one of the green sands of the Cook Mountain or Mount Selman formations is at the surface, the uplift may generally be defined by running elevations on it and contouring.

Around the old domes of East Texas where the salt is less than 400 feet below the surface, the surface dips are generally very steep. It is an interesting fact that around some of the new domes where the salt is even within 500 or 600 feet of the surface the surface dips may not be more than two degrees, while a dome that is considerably deeper may reflect considerable deformation at the surface.

#### DESCRIPTION OF DOMES BY COUNTIES

##### ANDERSON COUNTY

*Bethel dome.*—In the northwestern part of Anderson County near Bethel, which is about 18 miles north-northwest of Palestine, the Pure Oil Company discovered the structure known as the Bethel dome. The Pure Oil Company's J. R. Cook No 1 which is assumed to be located near the top of the structure was drilled in the fall of 1927 and discovered the anhydrite cap at 1,440 feet, and the salt at 1,600 feet. A sample log of this well (Table II) based on microscopic examination of the samples and cores has been furnished by N. L. Thomas of the Pure Oil Company.

*Salmon prospect.*—At Salmon, which is on the Missouri Pacific Railroad about 14 miles south of Palestine and less than a mile north of the Houston County line, there is a structure which some have called a salt dome, but it seems very doubtful if there is a salt dome here. The surface along the railroad shows that there is structural disturbance, possibly a fault. The several companies that have "shot" this area are not all in accord and have not divulged the results of their seismograph tests. The structure has been known for a considerable time and most of the major companies which operated in East Texas have leases on it.

*Cronin structure.*—About 6 miles south of Palestine, near Cronin switch on the Missouri Pacific Railroad, there is a structure which was discovered by the Roxana Petroleum Corporation. At least two of the other companies which have "shot" this area reported there was no salt dome here and with this conclusion the writer believes that the Roxana seismologists agree and consider that this is probably a "high"

TABLE II

SAMPLE LOG OF PURE OIL COMPANY'S J. R. COOK NO. 1, ON THE BETHEL DOME,  
ANDERSON COUNTY, TEXAS

<i>Probable Correlation</i>	<i>Lithology</i>	<i>Depth in Feet</i>
Carrizo	No samples. . . . .	100
	Very fine sand and a little shale. . . . .	200
Indio (Lignitic Wilcox)	Sandy lignitic shale and sandy limestone. . . . .	270
	Silty lignitic shale. . . . .	300
	Sandy lignitic shale. . . . .	350
	Sand, rock fragments. . . . .	360
	Sand and some sandy lignitic shale. . . . .	560
	Fine sand and some shale. . . . .	610
	Sand and sandy lignitic shale. . . . .	660
	Sand, lignite, and sandy lignitic shale. . . . .	720
	Sand and lignitic shale. . . . .	750
	Sand, sandy shale, and lignite. . . . .	770
	Sand and lignitic sandy shale. . . . .	830
	Sand and lignite. . . . .	840
	Lignitic shale. . . . .	870
	Sand and lignitic shale. . . . .	910
	Sand and lignite. . . . .	970
	Sandy shale and sandy lignitic shale. . . . .	1010
	Sand and some lignite. . . . .	1070
	Lignitic shale and lignitic sandy shale. . . . .	1140
	Sand and sandy lignitic shale. . . . .	1160
	Sand and sandy shale. . . . .	1190
	Sand, lignite, and lignitic shale. . . . .	1200
	Hard sandy limestone. . . . .	1360
	Shale and lignitic shale. . . . .	1380
	Shale, lignitic shale and glauconite; first plentiful fauna. . . . .	1400
Midway(?)	Gray shale, glauconite and limestone; sample tested oil in chloroform. . . . .	1440
Cap Rock	Calcite, stained with asphalt (core). . . . .	1445
	Gray shale, limestone, and glauconite (oil). . . . .	1460
	Cavity, lost returns. . . . .	1465
	Gray sandy shale, anhydrite, and glauconite. . . . .	1490
	Mainly anhydrite. . . . .	1600
Salt	Halite. . . . .	1605

Abandoned November 21, 1927.

as reflected by shooting on one of the chalks. Judging from the location of this structure it is very probable that it may be a fault. Since the companies were looking mostly for salt domes it is entirely probable

that, with the hurried "shooting" that was done in East Texas many subsurface "highs," especially if they do not have an uplift of several hundred feet, have been missed.

## ANDERSON AND CHEROKEE COUNTIES

*Boggy Creek or Carey Lake dome.*—This dome, which is in both counties, has already been briefly described.

## FREESTONE AND LEON COUNTIES

*Sand Lake or Oakwood dome.*—About 11 miles west-southwest of Oakwood and 2 miles north of the station of Keechi on the Missouri Pacific Railroad the Roxana Petroleum Corporation discovered a salt dome. This dome is mostly in Freestone County but the southern flank of it extends over into Leon County. It is often referred to as the Sand Lake dome but is called the Oakwood dome by the Roxana. This dome shows pronounced dips on all sides in the Queen City sand, in the Cane River greensand, and in the Carrizo. The Roxana's Marshall No. 1, presumably drilled on top of this structure in January, 1928, encountered the anhydrite cap at 703 feet, and cored anhydrite cap to 877 feet, where the well was abandoned. A log of this well kindly furnished by the Roxana Petroleum Corporation follows (Table III).

## HENDERSON COUNTY

*La Rue dome.*—Northwest of La Rue, which is on the Texas and New Orleans Railroad in southeastern Henderson County and about 14 miles southeast of Athens, the seismologists of the Roxana Petroleum Corporation have discovered what is believed to be a dome. Although there are several surface dips in proximity to this dome between La Rue and New York, this is reported to be a deep dome.

## SMITH COUNTY

*East Tyler dome.*—About  $2\frac{1}{2}$  miles northeast of the Courthouse and just northeast of the city limits of Tyler, the seismologists of the Humble Oil and Refining Company discovered a dome which they have designated the East Tyler dome. San Augustine greensand fringes this dome on the east and dips eastward at a low angle, and the normal drainage lines are somewhat deranged. This dome has not yet been drilled and there is no exact information at hand as to the depth to the salt here, though it is said to be a shallow dome.

*Whitehouse dome.*—The Humble Oil and Refining Company's seismologists discovered another dome about  $7\frac{1}{2}$  miles south of Tyler, and

TABLE III

DRILLER'S LOG OF ROXANA PETROLEUM CORPORATION'S C. H. MARSHALL NO. 1,  
ON THE OAKWOOD DOME, FREESTONE COUNTY

Location: 150 feet from northeast line and 150 feet from southeast line of D. E. Marshall Survey.

<i>Probable Correlation</i>	<i>Lithology</i>	<i>Depth in Feet</i>
Carrizo	Surface sand and clay . . . . .	49
	Sand and shale . . . . .	60
	Shale . . . . .	81
	Sand and shale . . . . .	150
Indio (Lignitic Wilcox)	Sand and lignite . . . . .	190
	Shale . . . . .	212
	Hard sand rock . . . . .	215
	Broken sand and shale . . . . .	300
	Sand . . . . .	430
	Shale . . . . .	450
	Sand and shale . . . . .	474
	Hard sand rock . . . . .	475
	Shale and sand . . . . .	577
	Hard sand rock . . . . .	578
	Hard sand and pyrites . . . . .	581
	Shale . . . . .	592
	Hard sand . . . . .	593
	Sand and shale . . . . .	630
	Sand . . . . .	703
Cap rock	Cap rock . . . . .	877

Cored cap rock at 703, 730, 751, 771, 781, 791, 801, 814, 825, 841, and 857 feet. Drilled by Shubert Drilling Company of Dallas, Texas (contractors), for Roxana Petroleum Corporation.

Commenced drilling, January 16, 1928. Completed drilling, January 23, 1928.

about  $3\frac{1}{2}$  miles northwest of Whitehouse, both of which are on the Missouri Pacific Railroad. G. M. Knebel and L. W. MacNaughton of the Humble Oil and Refining Company have recently completed a topographic map of this dome which shows a central basin encircled by hills. The San Augustine greensand caps these hills and dips away from the center of the dome at a low angle.

The Humble, Van Hovenberg and Anderson well, located 150 feet from the north line and 1,523 feet from the east line of the Van Hovenberg and Anderson 220-acre tract in the Nancy Charles survey, drilled in February, 1928, encountered the anhydrite cap at 487 feet. A log of this well kindly furnished by Wallace E. Pratt of the Humble Oil and Refining Company follows.

## SALT DOMES IN EAST TEXAS

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TABLE IV

DRILLERS' LOG OF HUMBLE OIL AND REFINING CO., H. M. VAN HOVENBERG *et al.*  
NO. 1A ON THE WHITEHOUSE DOME, SMITH COUNTY

Location 50 feet from south line and 200 feet from west line of H. N. Van Hovenberg *et al.* 50-acre tract, Nancy Chile survey.

Formations	Lithology	Depth in Feet
Queen City and Wilcox	Sand.....	3
	Sandy clay.....	49
	Rock.....	51
	Clay.....	81
	Sandy clay.....	111
	Rock.....	112
	Shale.....	142
	Rock.....	143
	Shale.....	181
	Sand and boulders.....	196
	Sandy boulders.....	202
	Shale with sand streaks.....	232
	Hard sand.....	261
	Shale.....	271
	Hard sandy shale.....	294
	Sand.....	301
	Hard sandy shale.....	312
	Sand.....	334
	Shale.....	346
	Sandy shale.....	352
	Hard sandy shale.....	358
	Rock.....	359
	Pack sand.....	374
	Pack sand and boulders.....	390
	Shale.....	395
	Hard sand.....	396
	Sandy shale.....	403
	Rock.....	406
	Hard sand.....	409
	Hard sand.....	410
	Rock.....	412
	Hard sand and boulders.....	416
	Rock.....	423
	Sand and boulders.....	431
	Rock.....	433
	Sand and boulders.....	439
	Sandy shale.....	465
	Rock.....	467
	Sand rock.....	468
	Rock.....	471
	Hard shale and lignite.....	480
	Rock.....	483
Cap rock	Anhydrite.....	485
	Hard sand.....	492
	Anhydrite.....	550 T.D.
		Drill stem stuck and abandoned

Commenced, January 14, 1928.

Completed, March 1, 1928.

*Mt. Sylvan dome.*—About 9 miles west-northwest of the Courthouse of Tyler, and east of Neches River near the latter's junction with South Prairie Creek, the Humble Oil and Refining Company's seismologists have discovered another dome. The San Augustine greensand, though dissected by drainage lines, partially encircles this dome. The dips around this dome are reported to be very gentle. This dome has not been drilled as yet but it is said that the salt here is shallow. A salt spring and several salt licks occur near the dome.

*Bullard dome.*—About 2 miles northeast of Bullard, which is on the St. Louis and Southwestern Railroad, the Gulf Production Company discovered a dome with the aid of seismographs. The San Augustine greensand partially encircles this dome and there are steep dips in the Mount Selman sands at the surface. The Gulf's Annie Morgan *et al.* No. 1, a log of which follows, encountered salt at 527 feet.

TABLE V

LOG OF GULF PRODUCTION COMPANY'S ANNIE MORGAN *et al.* NO. 1, BULLARD DOME, SMITH COUNTY

Location: 500 feet northwest along east line from southeast corner of Mrs. S. A. Morgan *et al.* 67.5-acre tract (from center line road) and 150 feet southwest at right angles to said line in Vinson Moore League.

Lithology	Depth in Feet
Sand and surface clay .....	50
Sand .....	175
Sticky shale .....	375
Crystallized gypsum with streaks of shale and lime .....	527
Salt .....	531

Commenced drilling, October 26, 1927. Completed, November 4, 1927.

*Troup dome.*—About 3 miles northwest of Troup, on the east fork of Mud Creek, the Amerada Petroleum Corporation, according to their seismologists, have located a dome. There are no data at hand here as to the depth to the salt, but this is reported to be a fairly deep dome. There is little or no evidence of deformation at the surface.

## WOOD COUNTY

*Haynesville or Mineola dome.*—Along Lake Fork Creek, about 8 miles northeast of Mineola, which is on the Missouri Pacific Railroad, the Gulf Production Company's seismologists claim another salt dome. This is sometimes referred to as the Mineola dome. The writer has

been advised that the San Augustine greensand comes up on the east side of this dome and ends abruptly and that there are some steep dips in proximity to the structure.

#### GEOLOGY

It is not within the scope of this paper to discuss the geology of East Texas in detail, but the sands which may be looked upon as prospective producers of oil and gas are briefly described. For the convenience of those desiring a general outline of the stratigraphy of this region, the accompanying table of Eocene and Upper Cretaceous formations is included (Table I), the data for this table having been obtained largely from a study of logs and cores of wells in Freestone, Anderson, Cherokee, Henderson, Van Zandt, Smith, Nacogdoches, and Houston counties.

#### PROSPECTIVE PRODUCING SANDS

##### EOCENE

*Sands in the Cook Mountain and Mount Selman formations.*—Near the top of the Queen City sand showings of oil have been reported in several wells, and in this connection it may be mentioned that the oil in the old Nacogdoches shallow field in Nacogdoches County is obtained from the Queen City sand, just below the base of the San Augustine greensand. The wells in the Nacogdoches field are small, generally yielding 2-4 barrels per day, and the oil is of heavy gravity. About  $\frac{1}{2}$  mile northwest of Jarvis, in southern Anderson County, there are asphaltic sands from which oil seeps. This horizon is in the lower part of the Mount Selman formation and possibly somewhat lower in the section than the horizon from which production is obtained in the Nacogdoches field. The top of the Queen City sand is at the surface around the salt domes of East Texas.

*Wilcox sands.*—The Wilcox formation consists mostly of gray and brownish-gray sands and clays, both lignitic and non-lignitic. There are several thin beds of concretionary limestone and hard sandstone. The sands at several places throughout the Wilcox section have yielded fair showings of oil, but as yet no commercial production has been obtained. It is hardly likely that they will prove as favorable as the Cretaceous sands. Good showings of gas have also been obtained from the Wilcox sands.

The Palestine Oil and Development Company's Monnig No. 1 (total depth, 2,200 feet), located near Long Lake in southwestern Anderson County, obtained gas from a sand near the base of the Wilcox at

1,684-1,700 feet. For several years after this well was drilled it made gas through a 6-inch open hole, and although there was no casing in the well, it is reported that it continued to make about 500,000 cubic feet of gas per day. When this gas was ignited, even after four years, it would throw a flame 6 feet high and continue to burn until extinguished. The well has been plugged within the last few years. The well drilled by A. L. Bowers in 1916 (total depth, 1,687 feet), located a short distance north of Long Lake, still shows considerable gas from a sand at 1,669-1,683 feet, which is approximately the same horizon as the gas sand in the well previously described.

Near the Wilcox-Midway contact and possibly of Midway age, there are locally thin sands that are reported to have contained some shows of oil and gas.

#### UPPER CRETACEOUS

*Sands in the Navarro formations.*—In Anderson County, near the top of the Pecan Gap chalk, and from 250 to 350 feet above, there are rocks consisting in some places of sand, sandstone, and sandy shale, and in other places of thin interbedded limestones and shales. It is suggested that these beds may be the equivalent of the Nacatoch sand of Louisiana. Judging from well logs, this bed is not persistent, as its continuity cannot everywhere be satisfactorily traced. The Magnolia's Summers No. 1, recently drilled in eastern Cherokee County near Ponta, obtained good showings of gas from sand and sandy shale at 3,215-3,238 feet, which is 103-116 feet above the Pecan Gap chalk. This same sand horizon, which is below the probable Nacatoch horizon previously referred to, is also reported in the Humphreys wells a few miles north, in Cherokee County.

*Wolfe City sand.*—In the Taylor formation, below the Pecan Gap chalk, there is a greenish-gray glauconitic sand and hard gray calcareous sandstone. This sand horizon, which seems to be correlative with the Wolfe City sand, is generally just below the Pecan Gap chalk, but is separated from the chalk in places by 10 to 100 feet of dark gray shale. The Wolfe City sand in East Texas ranges from 70 to 150 feet in thickness with 20 to 50 per cent sand, the remainder of the interval being limestone and shale. Good showings of oil or gas have been obtained from this sand in a number of wells and it is entirely probable that commercial production may be obtained from this sand under a favorable structure.

*Other sands in the Taylor formation.*—Although the Taylor formation below the Wolfe City sand generally consists mostly of shale with a few

thin limestone beds, some logs record a considerable amount of sand and sandy shale between the Wolfe City sand and the Austin chalk, so that it is possible that a producing sand may be found in this interval.

*Woodbine sand.*—There is a considerable variation in the composition and texture of the Woodbine sand. It consists mostly of light gray and tan, coarse- to fine-textured indurated sandstone, but there are beds of greenish-gray and brownish-gray sandstone and several thin beds of sandy shale. Thin lime beds interbedded with shale are also recorded in some logs. The drillers also log "Red beds." There are several of these red beds in the Woodbine section, generally from 5 to 20 feet thick, consisting of hard indurated clay with reddish and greenish colors.

The Humble, Elliott and Clark No. 1, on the east side of the Boggy Creek structure previously mentioned, was completed with an estimated yield of 10,000 barrels per day of pipe-line oil of 38.2° Bé. gravity after having topped the Woodbine at 3,842 feet and being drilled about 8 feet into the sand. As mentioned before, this well had to be shut in on account of lack of storage, and when finally allowed to flow, it soon declined to about 75 barrels of oil per day with considerable salt water. This well was subsequently deepened and reached the base of the Woodbine at about 4,087 feet, thus showing about 245 feet of Woodbine, 60 per cent of which was sand, the remainder being mostly shale with some lime. Although several oil-saturated sands were cored, when tested with a Lewis tester they showed only salt water.

The Humble's Spencer Clemons No. 3, on the west side of the Boggy Creek structure, topped the Woodbine sand at about 3,651 feet and went out of it at about 4,053 feet, giving a thickness of about 401 feet. Sixty per cent of this section was sand, but at this location there were few, if any, oil-saturated sands in the Woodbine.

The Humble's Elliott and Clark No. 2, 150 feet west of the discovery well, was completed, making about 10,000,000 cubic feet of gas with 720 pounds pressure, and is still holding up after two months. The gas is reported to yield considerable gasoline, but the exact amount is unknown. Gasoline accumulates in the well, and when blown out the pressure increases considerably, it being reported that it often increases to 1,300 pounds per square inch. This gas is from 13 feet of Woodbine at a depth of 3,519 feet, which is underlain by shale also of Woodbine age.

The Humble's Lizzie Smith No. 1, on the south side of the same structure, topped the Woodbine at 3,714 feet and is making about 90

barrels of oil per day by heads from about 4 feet of sand. Swabbing tests indicate that this well will doubtless produce several hundred barrels per day by pumping. Several of the other wells drilled by the Humble Oil and Refining Company on the Boggy Creek structure have found the Woodbine pinched or faulted out, and others have found the Woodbine present but somewhat thinned.

The log of the Humble's Southern Pine Lumber Company A2, on the Jarvis fault southeast of the Boggy Creek structure in Anderson County, encountered the Woodbine sand at 4,391 feet and passed out of it at about 4,929 feet, thus giving a thickness of about 538 feet. Fully 80 per cent of this section, which was cored in considerable detail, is sand. Numerous oil-saturated sands were found in the upper 250 feet but the well was not a commercial producer.

In eastern Cherokee County the Humphreys and Colliton interests proved that the Woodbine is at least 100 feet thick in that part of the county and several of these wells obtained oil-saturated sands in the Woodbine, but unfortunately no commercial production was obtained.

In western Van Zandt County, the Woodbine is known to be more than 400 feet in thickness.

From the foregoing description of the Woodbine sand, it is apparent that it is of considerable thickness in the central part of the geosyncline where the recently discovered salt domes occur, and that numerous individual sand beds in the Woodbine are oil-saturated. It is reasonable to expect that commercial production will be obtained from the Woodbine sand on some of the structures in East Texas.

The oil from the Woodbine is a highly volatile light green oil of 38° to 40° Bé. gravity when it comes from the well, but if left in an open container for a few hours, it rapidly loses some of its volatile constituents and the gravity changes to 25° to 28° Bé.

*Eagle Ford formation.*—In the vicinity of the Boggy Creek dome and near Jarvis in eastern Anderson County where several wells have penetrated the entire Eagle Ford formation it is less than 100 feet thick with little or no sand, but on the Keechi dome where the Eagle Ford is thicker the logs show that it contains some beds of sand in which oil showings have been reported.<sup>1</sup> However, at the north in Van Zandt County where the Eagle Ford is at least 465 feet thick it contains several beds of sand and sandy shale in the upper 150 feet of the formation, but, so far, these sands have yielded only small showings of oil and salt water.

<sup>1</sup>Sidney Powers, "Interior Salt Domes of Texas," *Geology of Salt Dome Oil Fields*, Amer. Assoc. Petrol. Geol., 1926.

It is entirely possible that these sands in the Eagle Ford formation will yield commercial production on a good geologic structure.

#### LOWER CRETACEOUS

*Basement sand of Trinity group.*—Several of the Humble Oil and Refining Company's wells on the Boggy Creek structure have encountered the Georgetown limestone of the Lower Cretaceous at 3,500 feet, and the Humphreys Oil Corporation is reported to have encountered the Georgetown at less than 4,500 feet in eastern Cherokee County. The Humble's Earl and Ragsdale No. 3, on the Boggy Creek dome in western Cherokee County, had a core at 3,695–3,700 feet, consisting of hard dark gray fossiliferous limestone lithologically resembling the Glen Rose, and the writer has been advised that this well did obtain the Glen Rose, but after passing through a body of lime and shale below 3,700 feet; the anhydrite cap of the salt dome was encountered at 3,885 feet, and the salt at 3,897 feet, so that the Humble was unable to determine whether the basement sand of the Trinity group underlies the central part of the East Texas geosyncline. This well, however, showed that, since the Glen Rose formation was found at this depth, it is entirely possible that the basement sand of the Trinity group, if it is present, will be found around some of the East Texas salt domes at a depth of less than 5,000 feet. If it is present it may of course be considered as a possible source of commercial production.

It is also very probable that within the next few years the drilling in proximity to these domes will throw light as to the source of salt and the age of the rocks underlying the Lower Cretaceous, a much discussed question of considerable scientific interest. The fact that such a large part of the Lower Cretaceous has already been penetrated without encountering beds of salt, seems to argue for pre-Cretaceous age of the original salt deposits.

#### THEORETICAL CONSIDERATIONS AND CONCLUSIONS

There has been sufficient drilling in the East Texas geosyncline to show that the Lower Cretaceous consists largely of brittle limestones (Buda, Georgetown, and Glen Rose), and that the Upper Cretaceous contains a considerable amount of chalk and hard limestone (Austin and Pecan Gap chalk). A salt mass penetrating rocks of this type will necessarily fracture and fault them to a considerable degree. Up to date the development work of the Humble Oil and Refining Company in proximity to the Boggy Creek dome has shown that the symmetrical arrange-

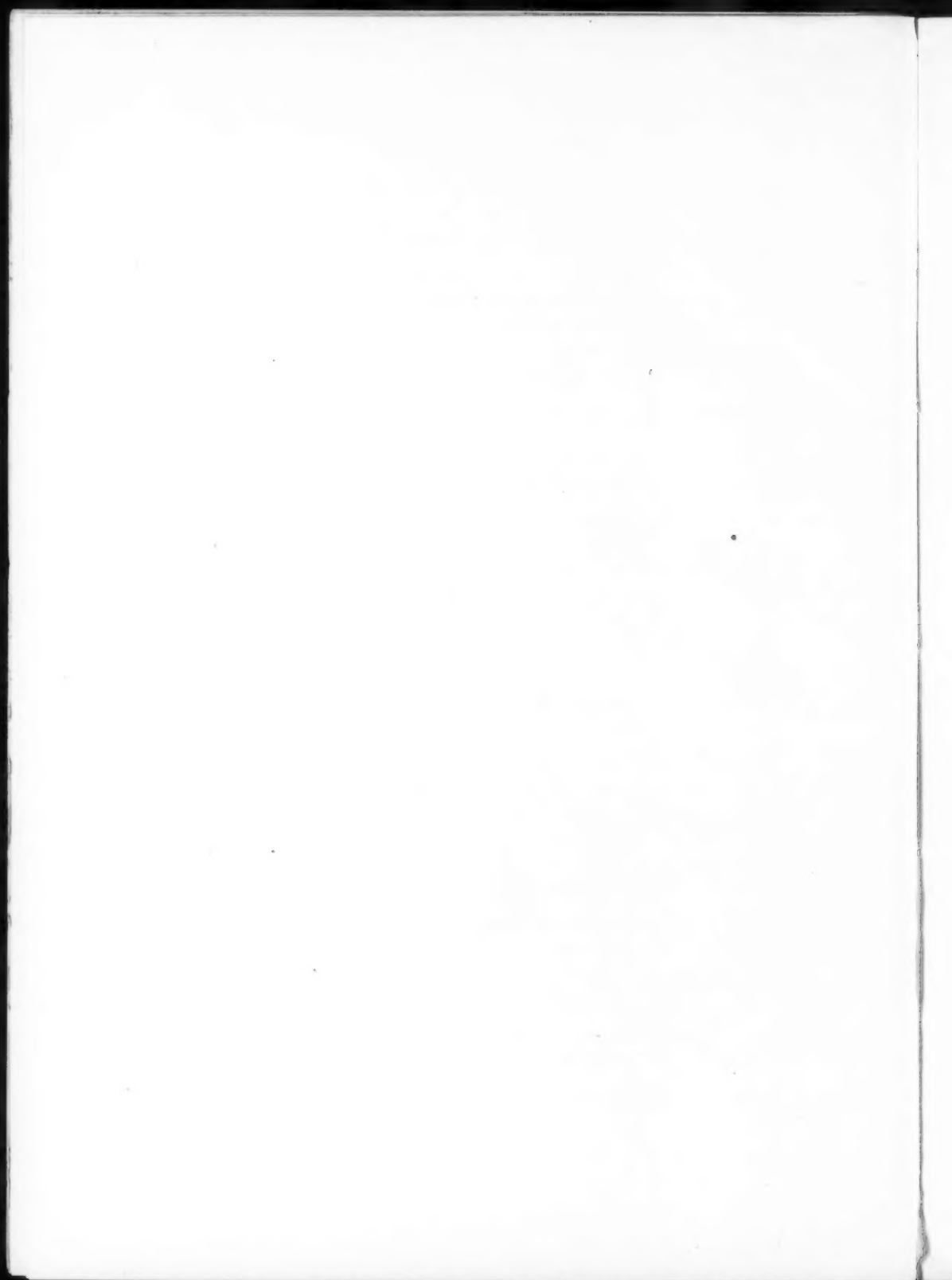
ment of the sedimentary rocks around the dome has been disturbed considerably by faulting, and the complication of the faulting on the surface at the Palestine dome, where the Buda limestone of the Lower Cretaceous is at the surface, is further proof of the complicated structure that may be expected around a dome where the salt has penetrated these brittle Cretaceous rocks. In the Gulf Coast of Texas and Louisiana, where the salt penetrates clays and shales with interbedded sands, all of which are more or less plastic and thus able to conform to the outline of the salt without great fracturing, there are numerous faults around the domes. It seems obvious, then, that there will be more deformation around the salt domes of East Texas, where the rocks are less plastic and more likely to fault and fracture.

It is reasonable to believe that the higher the salt has ascended into the Cretaceous rocks, the more it will deform them. For example, a salt mass, which has risen through the Upper Cretaceous and basal Tertiary, will obviously disturb and fracture the Upper Cretaceous and basal Tertiary as well as the Lower Cretaceous, more than a salt mass which has penetrated only the Lower Cretaceous. Hence, the deeper the dome, the more regular the sands are likely to be, and the better the chance of finding the producing sand since it will not be confined to such a narrow belt and may extend over the top of the structure. It is understood, of course, that the salt must have risen sufficiently high to reflect a subsurface structure in the prospective producing sands. As the sands will probably be easier to find on a relatively deep dome, it should be less expensive to develop, an important item in connection with the development of a salt dome which is the most expensive type of structure to explore with the drill. As a theoretical case we might say that if we find a salt dome which has penetrated only the basal Upper Cretaceous, we may reasonably expect to find production from the Woodbine around the periphery of the salt with good prospects of finding production from some of the sands in the Taylor and Navarro, and even the Wilcox, on top of the salt. In a situation of this type the cap rock might produce.

As an ideal dome would then seem to be one where the salt plug had penetrated only the lower Cretaceous but which had uplifted the Eagle Ford, Woodbine, and overlying sands sufficiently to produce an anticlinal structure in these sands above the Lower Cretaceous. In this connection, if there is a pronounced "high" on one of the chalks, as recorded by seismographic or subsurface work, it may, of course, mean that there is a deeply buried salt plug which has not pen-

etrated the chinks and also may not have penetrated the Woodbine sand. If a structure of this type should have sufficient closure, production would normally be expected from the Woodbine (and possibly higher) sands the same as on an anticlinal high.

There are several faults in East Texas with structural highs adjacent, but as this paper includes only the newly discovered salt domes and associated structures, the faults are not discussed.



## GEOLOGICAL NOTES

### WORLD RECORDS IN OIL PRODUCTION

On August 10, 1927, two world records in the production of crude petroleum were established: (1) for the first time in the history of oil, a single political unit—the United States of America—reached a total

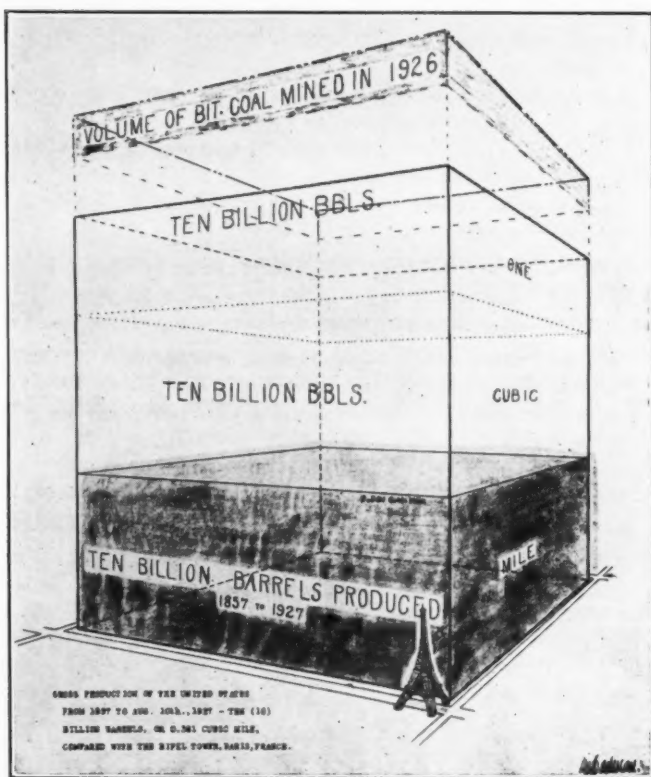


FIG. 1

gross production expressed in eleven figures, or 10,000,000,000 barrels; (2) for the first time in the history of oil, the United States produced one billion barrels of oil in the remarkably short time of 1.189 years or one year and sixty-nine days.

## VOLUME OF OIL

*Ten billion barrels*

Equals 56,145,833,333 cubic feet of oil.

Pumped into a cubical tank, one mile on a side, it would fill the tank to a depth of 2,013.95 feet, and would be equal to 0.381 of a cubic mile in volume.

Pumped into Crater Lake, in Oregon, it would raise the level of the lake 100 feet.

It would fill a trough 10 feet wide and 10 feet deep, long enough to go around the earth at the equator, 4.27 times.

It would fill 181,818 fifty-five-thousand-barrel tanks, which, if placed wall to wall, would cover an area of 85.6 square miles.

It would cover the present producing area of the United States to a depth of 0.56 of a foot.

It would cover the states of Rhode Island and Delaware to a depth of 6 inches.

## RATE OF PRODUCTION

Table I furnishes some rather interesting information.

The industry, during its formative and infant days, was 43.942 years in producing the first billion barrels of oil. The infant has grown

TABLE I

RATE OF OIL PRODUCTION IN THE U. S. A.

<i>Billion Bbls.</i>	<i>Time in Years</i>	<i>Difference in Years</i>	<i>Percentage of Total</i>	<i>Time in Years</i>
<i>Read</i>		<i>down</i>	<i>Read</i>	<i>up</i>
1st	43.942	.....	100	70.608
2nd	8.137	35.805	90	26.666
3rd	4.641	3.496	80	18.520
4th	3.526	1.115	70	13.888
5th	2.784	0.742	60	10.362
6th	2.331	0.453	50	7.578
7th	1.376	0.955	40	5.245
8th	1.345	0.031	30	3.871
9th	1.337	0.008	20	2.526
10th	1.189	0.148	10	1.189

into a giant, which produced the tenth, or last, billion barrels in the short period of 1.189 years, or one year and sixty-nine days.

The right-hand column of Table I, reading up from the bottom, shows that one-tenth of our oil was produced in 1.189 years; one-half was produced in 7.578 years, or since the Armistice in 1918; nine-tenths was produced in 26.666 years, or 17.276 years less than the time it took to produce the first billion barrels.

#### HOW LONG?

How long will our home supply of oil last? The answer to this question depends upon several factors.

*Factor 1.* The amount of oil now in the ground that can and will be produced. This is an unknown factor. The most careful estimates have been upset by developments, and experience shows that one good estimate soon requires another. Nothing along this line has been produced to date except revisions and debates.

*Fact 2.* The rate at which our present known sources are being produced. This is a variable factor,—1.345 years per billion barrels for the eighth billion-barrel period, 1.337 years per billion barrels for the ninth billion-barrel period, 1.189 years per billion barrels for the period ending August 10, 1927, *et cetera*.

*Factor 3.* The rate at which new oil will be found. This is both an unknown and a variable factor.

Estimates of the future supply of oil have varied between the widest limits. On the one extreme we have the early exhaustionists, who sound the warning that "it won't be long now,"—eight or ten years; on the other extreme we have those who suffer from a Pollyanna complex, who preach that "everything's going to be all right"—for a hundred and fifty to two hundred years, or more.

The true answer to the question is *somewhere* between these two extremes; *where*—that is just the question.

As far as the future supply of American crude is concerned, Uncle Sam is driving his hundred million cylinder car down an unknown road to somewhere—in high, a dark night, and dim lights.

#### RATE CURVE

An examination of the production rate curve (Fig. 2), shows some very interesting features.

(1) More than one-half of the oil produced in the United States has been produced since the Armistice, November 11, 1918.

(2) "The Deluge of 1921" is the greatest flood of new oil the industry has ever seen. Five major pools—Santa Fe Springs, Long Beach, Tonkawa, Haynesville, and Mexia, were discovered in the same year. Santa Fe Springs reached peak production of about 350,000 barrels per day by 1923; Long Beach reached its peak of about 260,000 barrels per day in the same year; Tonkawa reached its peak of more than 100,000 barrels per day in 1923; Haynesville reached its peak of about 100,000 barrels per day early in 1922; Mexia reached its peak of about 150,000 barrels per day in January of the same year.

The influence of this flood of oil is clearly shown by the curve, in the difference between the *previous tendency of the curve* and the actual curve, beyond the sixth billion-barrel period. This deluge of oil, through the seventh, eighth, ninth, and tenth billion-barrel periods, *decreased* the rate of producing one billion barrels of oil by an average of 0.575 of a year.

(3) The flattening of the curve from the seventh to the tenth billion-barrel period strongly suggests the approach of a peak in the gross production of oil in the United States. Between the seventh and eighth periods there was a decrease of 0.031 of a year; between the eighth and ninth periods a decrease of 0.008 of a year; between the ninth and tenth periods a decrease of 0.148 of a year.

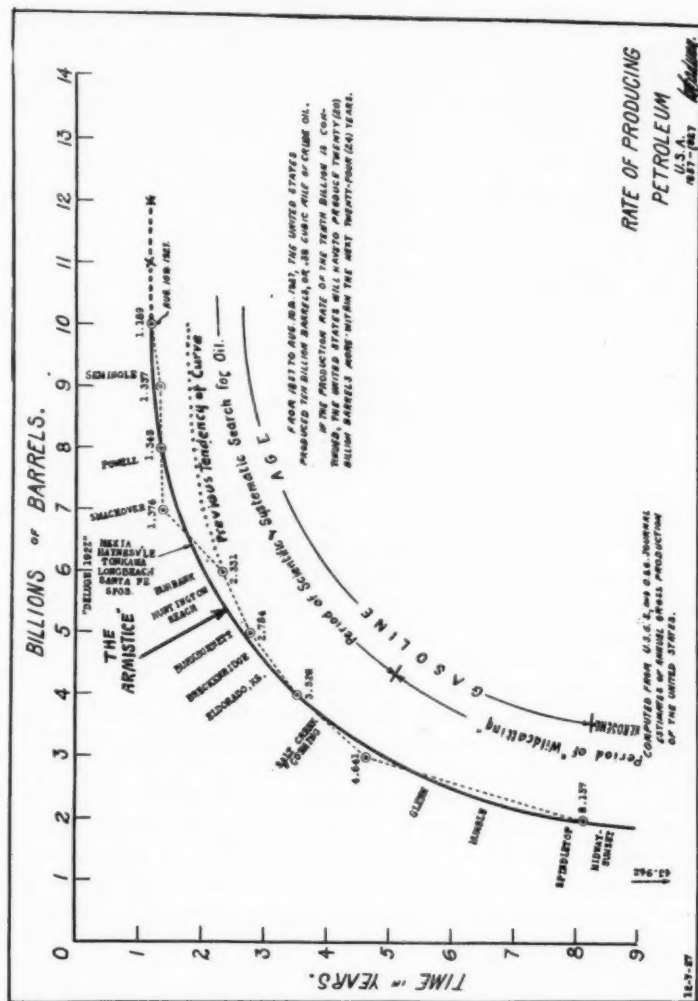
It would seem that the "Deluge of 1921" and the following Smackover, Powell, and Seminole floods are just about holding their own in maintaining the high rate of production against the natural decline in production of all fields during the same period.

(4) If the production rate of the tenth billion-barrel period is continued, the United States will have to produce twenty billion barrels more oil within the next twenty-four years.

#### CONCLUSIONS

Petroleum is the supreme source of power in the present day of internal combustion motors. Easily and safely carried, flowing to its task, it performs a service for man—the most efficient, the most adaptable, and the most convenient known. The nation that uses its petroleum wisely lays a foundation for continued or future greatness and power.

In the matter of petroleum, this nation should be completely for conservation that *can serve*. Conservation that can serve is a blessing; conservation that can't serve is a curse. There is too much oil to hoard; there is not enough to throw away.



**FIG. 2**

Until the human nature of men and nations has a great change for the better, oil *in our own back yard* will always be premium oil.

W. K. CADMAN

WICHITA, KANSAS

March 5, 1928

#### SYNCLINAL OIL OCCURRENCE AND REGIONAL UPLIFT

It is a matter of common knowledge that in some regions buried sands are either dry or are only partially saturated with water, and that, in consequence, such oil pools as are present tend to occur in synclines, or perched on terraces on the limbs of synclines, rather than beneath anticlinal crests. Such synclinal accumulations are, so far as the writer is aware, found in regions which have been undergoing upwarp and erosional unloading for a considerable period, and this relationship is believed to afford the clue to the partial or complete lack of water in sands which undoubtedly were once saturated. As has been pointed out by many writers, the muds and clays interbedded with sand beds, as originally deposited, contained very large percentages of interstitial water. With progressive burial, however, the muds are compacted, and water is either forced from the muds directly to the surface, or is indirectly discharged (up to the limiting hydrostatic pressure) through the associated porous beds. In any event, a greater or less amount of water is squeezed out of the shale or clay beds, and these beds are subjected to a certain amount of cubic compression.

If now, following a period of compacting and water expulsion, the region were uplifted and partly unloaded by erosion, the compressed shale beds would show a certain elastic response to the unloading, causing the openings between the clay particles to increase in size, and the finer-grained beds, because of their capillary adsorptive power, would take water from the coarser-grained beds near by, much as blotting paper might do (and as illustrated by the absorptive capacity of shale fragments obtained from depth). It is also possible that minerals present in clays and shales may assume an anhydrous or slightly hydrated form under certain pressures, and change over to a more highly hydrated form when pressure and temperature decrease to a certain point—such increase in hydration tending to “use up” the amount of uncombined water in the vicinity.

It seems probable that the idea that there is a causal relation between regional upwarp (and denudation) and synclinal oil occurrence

is by no means novel, although original in so far as the writer is concerned. It is nevertheless presented because there are practical problems connected with such oil occurrence, or with the "dryness" of sands, which otherwise do not seem capable of rational explanation.

W. T. THOM, JR.

PRINCETON, NEW JERSEY

March 16, 1928

#### AN EARLY REFERENCE TO THE THEORY THAT DIATOMS ARE THE SOURCE OF BITUMINOUS SUBSTANCES

Much has been said recently on the theories of the origin of oil and the general conclusions seem to have been reached that microscopic organisms in some way have been the chief contributors to the supply. Among the micro-organisms the diatoms have received a considerable amount of attention because of the close association of some vast deposits of them with well known accumulations of bituminous substances. This conclusion is likely to be reached by anyone who makes a study of either the diatoms or the oil but it is interesting to know who was the original founder of the theory.

F. M. Anderson,<sup>1</sup> in an excellent historical retrospect, recently traced the theory back to J. D. Whitney<sup>2</sup> in 1865-67. C. F. Tolman<sup>3</sup> later likewise gave Whitney credit for the conception of the theory of the diatom source of much of the oil. Others have not gone so far back in the literature.

No one person has ever studied diatoms as extensively as did C. G. Ehrenberg<sup>4</sup> between the years 1837 and 1875. It would be remarkable if at some time it had not occurred to him that petroliferous substances originated with the fossils he studied and for some years it has been suspected that he mentioned the matter in some of his many publications. A search has shown that he did actually publish a paper on the subject in 1839 under the title, "Ueber die Dysodil genannte Mineralspecies als ein Product aus Infusorienschalen." Dysodil is a name given to as-

<sup>1</sup>F. M. Anderson, *Bull. Geol. Soc. Amer.*, Vol. 37 (1926), pp. 585-614.

<sup>2</sup>J. D. Whitney, *Geol. Survey of Calif.*, Vol. 1 (1865), pp. 117, 126, *et seq.* Also *Proc. Calif. Acad. Nat. Sci.*, Ser. 1, Vol. 3 (1867), p. 319.

<sup>3</sup>C. F. Tolman, *Econ. Geol.*, Vol. 22 (1927), p. 461.

<sup>4</sup>C. G. Ehrenberg, *Poggendorff's Annalen der Physik und Chemie*, Ser. 2, Vol. 48, Pt. 4, No. 12 (1839), pp. 573-75. For abstracts see: *Annal. des Mines*, Vol. 18 (1840), pp. 51-52; *Annal. Nat. Hist.*, Vol. 5 (1840), p. 150; *Microscopical Record*, Vol. 1 (1841), pp. 107-08.

phaltum or bitumen by Cordier in 1808. Ehrenberg used the name "Infusoria" for diatoms and did not restrict the term to non-silica-bearing organisms as do modern biologists. This is made clear in the text of his paper by his mention of the genus *Navicula* in particular.

It is possible that Whitney may have derived some of his ideas from this paper or from letters from Ehrenberg, since these men are known to have been in correspondence; however, nothing has been seen in the literature to indicate that the theory was not an original deduction by Whitney just as the same conclusion has undoubtedly been reached independently by many other workers since Ehrenberg wrote.

G. DALLAS HANNA

CALIFORNIA ACADEMY OF SCIENCES  
SAN FRANCISCO  
March, 1928

#### LIMESTONES AS A SOURCE OF OIL<sup>1</sup>

The question of whether or not limestones can be source beds of oil has been difficult to settle definitely. Although in many places the bituminous nature of a limestone or the absence of other "possible" source beds has suggested strongly that limestones may be mother rocks of petroleum, yet it has been difficult to rule out the possibility that the bituminous character of the limestone, or the oil in an adjacent pool, has been due to the inward migration of petroliferous substances from other sources.

However, if limy sediments accumulating to-day be found to be bituminous, the possibility of migration of petroliferous substances into such deposits from other sources is practically eliminated, and the probability of limestones as source beds becomes strong.

To help settle this question, the reconnaissance of the organic nature of different types of recent sediments, conducted as American Petroleum Institute Research Project No. 4, included the limestone-forming deposits of the Florida Keys and the Gulf of Batabanó in southern Cuba. The Florida region was particularly interesting because previous work of T. W. Vaughan<sup>2</sup> suggested a considerable organic content for the calcareous deposits of that district.

<sup>1</sup>This paper contains preliminary results of an investigation on "The Origin and Environment of Source Sediments," listed as Project 4 of American Petroleum Institute Research. Financial assistance in this work has been received from a research fund of the American Petroleum Institute donated by Mr. John D. Rockefeller. This fund is being administered by the Institute with the co-operation of the Central Petroleum Committee of the National Research Council.

<sup>2</sup>Oral communication and "Oceanography in its Relations to other Earth Sciences," *Jour. Wash. Acad. Sci.*, Vol. 14 (1924), p. 320.

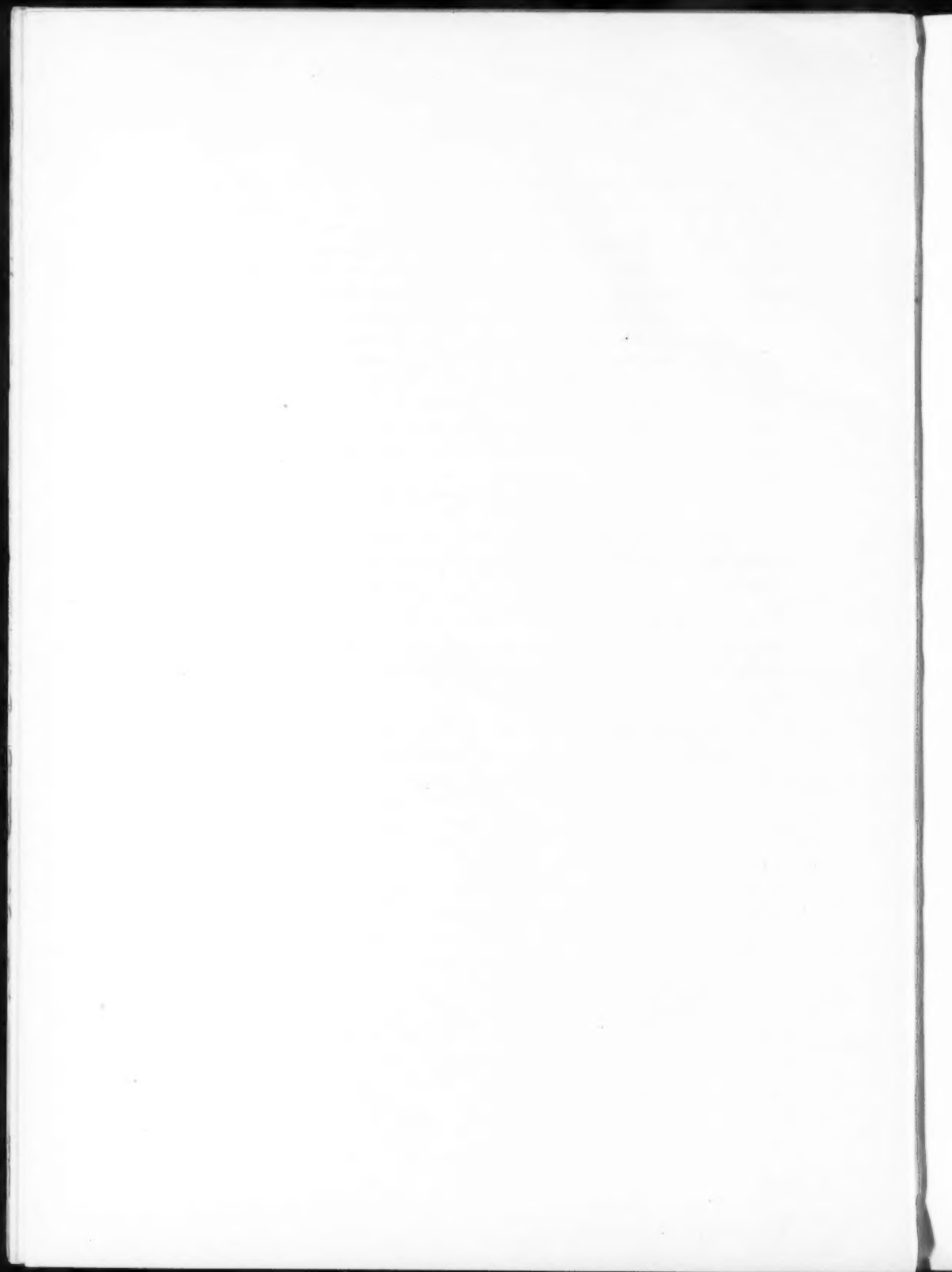
The organic status of the sediments collected in this survey was ascertained by distilling the dried sample in the same way in which oil shales are assayed. A great variety of sediments from many different regions have been distilled. The maximum yield from marine deposits has been found to be 2.5 gallons a ton. Sediments from four regions gave this amount, namely, those from Lake Maracaibo, Pamlico Sound, Florida Bay, and the Gulf of Batabanó in Cuba.

At present insufficient data are at hand to ascertain if a yield of 2.5 gallons a ton indicates a good potential future source bed of petroleum, but the fact that one per cent of the total weight of these sediments can be caused to become volatile and condense to a liquid oil is very significant, and indicates that such beds are potential future source beds, although perhaps not so good as may have occurred in the past or may yet be discovered forming today.

The limy oozes accumulating in two widely separated regions, Florida Bay and the Gulf of Batabanó, both gave this maximum yield of 2.5 gallons a ton. The chance for possible contamination of oil from surface water or seepage from a buried non-limy formation is negligible. Consequently the evidence indicates that limestones may be source beds of oil. However, it is probable that they vary widely in their potentiality as source beds, for limy oozes from Key West,—a considerable distance from the mainland, but not far from Florida Bay,—gave only a faint trace of oil, and with present knowledge can not be regarded as potential future source beds.

PARKER D. TRASK

LA JOLLA, CALIFORNIA  
March 29, 1928



## DISCUSSION

### PLEISTOCENE OF SOUTHERN CALIFORNIA

I have read with interest Eaton's article dealing with the Pleistocene in southern California.<sup>1</sup> Apparently the author was not aware of a previous article by Carson<sup>2</sup> who supplied the region with an abundance of formational names.

HUBERT G. SCHENCK

STANFORD UNIVERSITY, CALIFORNIA  
March 15, 1928

Mr. Schenck seems to have misunderstood the principle governing the nomenclature used in my recent paper<sup>1</sup> on the Pleistocene of southern California, i. e., that of relevant priority.

The paper by Carson,<sup>2</sup> cited by Schenck, describes formations from different parts of California. One new name relevant to the Ventura-Los Angeles district was proposed: the Ventura formation. The description, fauna, and much of the locale given for this horizon (1925) apply to the Saugus formation of prior naming by Kew (1923). It is possible that two overlying formations of Pleistocene age were also included under the term, in which case it would be a sub-group, and equivalent to the upper Fernando of Eldridge and Arnold (1907). In either case it is a duplicate of previous nomenclature.

The following comment, with citations, is given for the information of those interested in the Pleistocene geology of Ventura and Los Angeles basins.

In describing the geology of the intimately related Ventura-Los Angeles district, the name commonly used by southern California geologists for each formation is that given by the first writer to recognize and *delimit* the unit, unless unquestioned correlation can be made with the standard column of California. The names used by the present writer to designate the Pleistocene and transitional Pleistocene formations in Ventura and Los Angeles basins are those in current use by research workers, and are with one exception those appearing on California Charts I to IV, compiled in January, 1927, by the Secretary, Committee on Geologic Names, United States Geological Survey. The exception refers to the recognizing, just recently, of a new and distinct unit.

The Pleistocene and transitional Pleistocene *formational* names commonly considered to have had prior usage are, reading up: *Saugus formation* (Kew,<sup>3</sup>

<sup>1</sup>J. E. Eaton, "Divisions and Duration of the Pleistocene in Southern California," *Bull. Amer. Assoc. Petrol. Geol.*, Vol. 12, No. 2 (February, 1928), pp. 111-41.

<sup>2</sup>Carlton M. Carson, "Pliocene Faunal Zones in Southern California," *Pan-Amer. Geol.*, Vol. XLIII (May, 1925), p. 269.

<sup>3</sup>W. S. W. Kew, "Geologic Formations of a Part of Southern California and Their Correlation," *Bull. Amer. Assoc. Petrol. Geol.*, Vol. VII, No. 4 (July-August, 1923).

1923); *San Pedro formation* (Eldridge and Arnold,<sup>1</sup> 1907); *San Pedro formation, restricted* (Kew, unpublished manuscript); *Hall Canyon formation* (Eaton,<sup>2</sup> 1928); and *Palos Verdes formation* (Kew, unpublished manuscript). In addition to the formational names cited, these sediments, with the exception of the Palos Verdes, are included in a great natural group, the *Fernando* (Hamlin, unpublished manuscript; and Eldridge and Arnold, *op. cit.*) whose definitions imply that it is of post-Monterey and pre-Sierran age. The various Pleistocene sediments are also included in and between the limits of the *San Pedro series* (Arnold,<sup>3</sup> 1903) a series term generally considered to embrace the post-Saugus formations.

J. E. EATON

628 PETROLEUM SECURITIES BUILDING  
LOS ANGELES, CALIFORNIA  
April 5, 1928

<sup>1</sup>George H. Eldridge and Ralph Arnold, "The Santa Clara Valley, Puente Hills, and Los Angeles Oil Districts, Southern California," *U. S. Geol. Survey Bull.* 309 (1907).

<sup>2</sup>*Op. cit.* Recognized and mapped in October, 1926, as a separate unit lying unconformably between the upper and lower *San Pedro series* in full section (Los Angeles meeting of the Association, October 29, 1926. Also *The Oil & Gas Journal* for November 11, 1926). First appearance of the name in an informal communication to M. Grace Wilmarth, October 27, 1927.

<sup>3</sup>Ralph Arnold, "The Paleontology and Stratigraphy of the Marine Pliocene and Pleistocene of San Pedro, California," *Calif. Acad. Sci. Mem.*, Vol. III (1903), pp. 12 and 54.

## REVIEWS AND NEW PUBLICATIONS

*Methods of Applied Geophysics.* By E. PAUTSCH. Distributed by the Gulf Publishing Company, Houston, Texas, 1927. 82 pp., 50 figs.  $7\frac{1}{8} \times 10\frac{3}{8}$  inches. Paper. Price, \$6.50.

Inasmuch as publications on Applied Geophysics are scattered in many different journals, principally foreign, and a textbook on this subject has not thus far appeared in this country, it certainly is a meritorious work that a scientist has gone to the trouble to comprehend the fundamental facts about the methods.

The paper deals with the subject chiefly in a mathematical way. Unfortunately no mention is made of actual results obtained by the geophysical methods; some illustrations of observations made over known structures would have been interesting. The author states in the preface that applied geophysics has been a carefully guarded secret of a few scientists, and that his book will be a truly scientific paper in contrast to the numerous articles published by persons who have not the necessary foundation. This is certainly true to a limited extent. On the other hand, such a general statement may perhaps be misinterpreted in view of the fact that there are a number of formulæ and figures in the author's book which have been taken from other geophysical publications without credit being given to them. There is also no reference made to any other geophysical articles; a literature list would certainly have increased the value of the book.

The first chapter, on gravity methods, covers satisfactorily the theory of the torsion balance. The reviewer does not quite agree with the author that pendulum measurements are inadequate for geophysical investigations. They are proving more and more their value in exploring large buried formations where too many torsion balance stations would be required. Inasmuch as satisfactory results have been obtained above granite ridges and salt domes, it might be advisable to include a chapter on pendulum measurements in the next issue. An illustration of a torsion balance should then also be included. The compilation of the formulæ and figures published by Eötvös, Meisser, Holst, Rybar, and Shaw for the effect of subterranean deposits is very useful; their value would have been somewhat increased if not only the formulæ for gradients but also curvature values had been stated.

The chapter on seismic methods is the best of the book. Simple derivations are given for the propagation of seismic waves using the idea of Fermat's principle, and are illustrated by the timegraphs for some types of unconformities. The principle of the various seismographs used in seismic stations is also illustrated.

The chapter on magnetic instruments seems to be decidedly too short, in view of the great variety of magnetic field instruments which are used at present. The principle of at least one magnetic instrument should have been

illustrated. The table of magnetic susceptibilities contains only minerals and not rocks, which are also of very great importance. Of the minerals, the strongly magnetic ilmenite has been overlooked; pyrrhotite and limonite should also have been mentioned. As to igneous rocks, granite is not mentioned as being magnetic, though its magnetism is a fact which is applied in magnetic oil exploration in Texas, Kansas, and Oklahoma. The use of magnetic prospecting in gold placer mining might have been mentioned. Siderite is disintegrated under ordinary conditions to hematite and limonite, not greenstone; in contact-metamorphic zones only may ferrous silicates be formed from siderite, but this is not a regular disintegration. The reviewer does not agree with the author that the theory is obsolete which conceives that the deposit is equivalent to one permanent magnet or several of them. The formulæ given by Thalen, Smyth *et al.* deserved mention in this connection. For anomalies produced by magnetism induced in the deposit, the author gives only a triple integral for the potential without deriving the forces. Formulæ for unconformities with geometrical outlines have been given by Haalck. Finally it is not correct that for research work relative magnetic measurements are used exclusively.

Unfortunately, the geothermal method has been completely omitted. Valuable data have been published, especially by the U. S. Geological Survey, in this line.

The electric method is again described in some detail, especially with reference to the theoretical foundation. Several important equations are derived for the resistance of conducting bodies and the theory of the distribution of currents in the earth.

The last chapter comprises a description of the radioactive method.

It would have been advisable to append an index at the end of the book.

C. A. HEILAND

GOLDEN, COLORADO

February, 1928

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*In a Persian Oil Field.* By J. W. WILLIAMSON. 189 pp., 24 illus., 1 map. London: Ernest Benn, Ltd., 1927.

This book, written in two parts with the first called *The Science* and the second *The Humanities*, is a study in scientific and industrial development as conducted by the Anglo-Persian Oil Company in the exploitation of its Persian holdings. Mr. Williamson, a lawyer, is secretary of the British Scientific Instrument Research Association and this volume is the result of one of his investigations. The book is intended for the general reader; consequently, it is largely of a non-technical nature.

The principal scene of operations is in the district of Masjid i Suleiman (Solomon's Temple) in the foothills of the Baktiari Mountains. The famous Maiden i Naftum field is in this area. The concession granted by the government covers nearly all Persia, but the principal development is still confined to the district discussed, although an important field has been opened in Iraq, near Bagdad.

The geologist reader, who, perhaps, would be most interested in the first part of the book, which deals with the finding, production, transportation, and refining of the oil, can readily sympathize with those pioneer geologists who had the arduous task of struggling over the extremely rough topography, of working in the desert climate, and of interpreting the geology. This interpretation is made especially difficult by incompetent plastic beds, mainly gypsum, which are here squeezed from between competent beds, thus masking true relationships.

The oil is found in simple, ideal domed and anticlinal structures in a limestone which crops out but seventeen miles away. The principal producing structure in the Masjid i Suleiman area is a great anticline with two superimposed domes, the Naftum and the Naftak domes. Although the topography is much dissected, the folding is visible to the eye at the surface. Considerable research has been done on the occurrence of oil and the evidence from various sources indicates that the oil occurs almost wholly in cracks, fissures, and channels in the main limestone and not in small cavities or pores of the limestone.

Geological work is prosecuted in the most approved scientific manner, each phase from reconnaissance to the latest geophysical means being rigorously investigated and applied. Thus, geological subsurface correlation and mapping from well data have proved to be of great value in the Masjid i Suleiman field and in test areas, while such geophysical means as the torsion balance, seismic methods, electrical methods, and magnetic methods are all being thoroughly tested to give supplementary evidence. A deep well has been drilled solely for geological information. Cuttings are taken from each well and sent to the geological department for examination and identification and, similarly, water samples are taken and analyses made.

Single control permits efficient, high percentage recovery of oil. Various pressures, namely, the minimum closed-in pressure, the flowing pressure, the maximum closed-in pressure, and the dome gas pressure are periodically measured and control applied in accordance with the data thus secured. This has resulted in an appreciable slowing down in the decrease of pressures while the rise in the oil-water and gas-oil levels has also been retarded. Apparently, the British engineers and geologists are mainly concerned with the gas-oil level, that is, the level at which the gas in the structure meets the surface of the oil, and not with the gas-oil ratio of the American technologists. The author believes the intensive investigations into the measurement and implications of these pressures are distinctly original.

Transportation, refining, and research are likewise conducted in accordance with the best of modern practice. The topography and soil provided difficult pipeline problems in getting the oil to the Persian seaboard, where one refinery is operated, while another is in Wales. Large complete research laboratories, also, are maintained both in Persia and England, attention being given to all sorts of problems directly or indirectly connected with the enterprise.

The scope of the company's activities has been scientific and intensive also in its treatment of the personnel, great pains having been taken to give fair treatment, provide good medical services, social activities and improved public

health, housing and education. The towns built by this great organization are possibly the most sanitary in either the near or far East.

It was a revelation to learn how thoroughly and scientifically the Anglo-Persian Oil Company is conducting its business. The Masjid i Suleiman field is probably the most efficiently developed oil pool in the world. The company has built modern industrial communities in the Persian wastes with the energy commonly associated with American enterprise. Its great capital and complete control of the fields, under intelligent leadership, has made this possible.

The book is pleasingly written and copiously illustrated, showing graphically some of the great difficulties surmounted and the results obtained.

HUGO R. KAMB

TULSA, OKLAHOMA  
February 28, 1928

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*Allgemeine Petrographie der "Ölschiefer" und ihrer Verwandten mit Ausblicken auf die Erdölentstehung (Petrographie der Sapropelite).* [Petrography of the Oil Shales and their Allied Substances with Views on the Origin of Petroleum (Petrography of the Sapropelites)]. By ROBERT POTONIE, Privatdozent at the Technical High School, Berlin. Verlag von Gebrüder Borntraeger, Berlin. 173 pp., 27 figures. Price, 12M.

This volume is complementary to the volume published by the same author in 1924 with the corresponding title "Allgemeine Kohlenpetrographie" [Petrography of Coal]. It deals with the bituminous rocks other than coals and those in which the bitumen occurs in liquid form. Its seven chapters discuss the following subjects: A, the concepts of bitumen and bituminous; B, the consideration of the bitumens from the petrographic standpoint; C, the principal petrographic types of the bituminous shales and closely related rocks; D, source, diagenesis, and metamorphism of the bitumens of argillaceous rocks; E, bitumen in more or less non-argillaceous rocks; F, the dependence of bitumenization on protobitumen and bitumen carriers; G, relations of the bitumens to igneous rocks.

Chapter A discusses very briefly the usage of the terms bitumen and bituminous and the range of materials they embrace.

In Chapter B, protobitumens are defined as the original organic substances from which the bitumens are derived. Most important are fats of plants and animals; less so are proteins, resins, terpenes, and balsams. Carbohydrates like cellulose are not protobitumens. Among the protobitumens are distinguished: (1) the stable, which include cutins, suberins, and resins, and (2) the labile, which include a wide range of fats, oils, and albumins. Waxes and caoutchoucs occupy an intermediate position. The stable protobitumens resist diagenesis and yield oil only through destructive distillation in the laboratory. Kerogens include the stable protobitumens and the stable metabitumens which are derived from labile protobitumens. With increasing depth, the stable metabitumens crack to petroleum through intermediate products called katabitumens, but this is not considered the principal source of oil.

Chapter C gives a petrographic classification of bituminous shales.

Chapter D discusses a series of topics bearing on the source of petroleum. After conceding the untenableness of Höfer's old idea that oil was derived entirely from animal remains, Potonié argues against the American tendency to ascribe its source to plants of which stable protobituminous parts are recognizable in the shales, such as cutins, and suggests that the minute organisms of plankton played an important rôle. He concludes that a satisfactory solution of the problem "animals or plants" cannot be arrived at petrographically. The labile protobitumens are not transformed directly to petroleum but are first transformed to stable metabitumens by processes that are little understood but in which the colloidal properties of the clay appear to play a part. Liquid oil is found in very small quantities in coal and bituminous shales and then only in cavities or sandy layers, so that we do not yet know the relation between the rock bitumen and the finished petroleum. The solution of this problem requires the consideration of whether there are various processes of bituminization and a recognition not only of temperature and pressure but also of the nature of the protobitumen and the composition and structure of its containing rock as possible factors in the processes. That the stable bitumens of the oil shales are not the source of the oil deposits, the author argues because of the inadequacy of decrease of pore space through pressure, replacement of oil by water, diffusion, and distillation, as processes to explain the migration of oil from the oil shales and because many of the older oil shales are still as rich in those substances as the best of the younger oil shales. The end product of metamorphism of oil shales is held to be anthracitization, the formation of black shales through the liberation of gases, and not liquid petroleum.

Because the argillaceous kerogen-bearing rocks show little evidence of liquid bitumens irrespective of their age or degree of metamorphism, and the non-argillaceous, porous and cavernous rocks show liquid bitumen even when they have been subjected to only moderate temperature and pressure, Potonié advances the theory in chapter E that the latter are not only receptacle rocks but also the source rocks of petroleum. The differences in conditions of sedimentation represented by clay and mud on the one hand, and sand and limestone on the other, were expressed also by primary differences in the character of the bitumen-carrying materials. The differences in the two groups of rock are twofold: (1) a primary difference in their protobitumens; (2) the character of the rock substance, which influenced the subsequent transformations of the bitumens. Evidence for primary petroleum and asphalt in addition to kerogen in limestones is presented. The conditions of formation of calcareous sediments are believed to be more favorable for the preservation of the labile protobitumens, and lime is held to accelerate their conversion to petroleum. The primary bitumen content of silicious rocks of organic origin is ascribed largely to the abundance of protein in such organisms as diatoms, which is considered an important petrol protobitumen. Porous sandy rocks are also regarded as primary sources of petroleum. Attention is called to the abundance of recent sapropelite sands and the conserving action of salt which is favorable to the accumulation of considerable protein, that is, labile protobitumen. The chapter concludes by emphasizing the idea that the important sources of oil are the more easily transformed labile protobitumens called the petrol protobitumens. They can be accumulated only where they are protected from

premature decay by high salinity or extreme stagnation. A rock containing mainly stabile protobitumens or even the less mobile labile protobitumens cannot be a source rock of petroleum. Out of such a rock results sapropelite coal. It happens that animal substances are characteristically richer in the petrol protobitumens, that is, fats, oils, and proteins, but these substances are not lacking in plants and particularly not in the lower plants. The problem of the animal or vegetable origin of oil hinges upon the determination of the animal or vegetable origin of the formless portions of the organic slimes which constitute the larger part of their petrol protobitumens.

Chapter F is a review of the ideas concerning the dependence of bitumenization on the nature of the protobitumens and the bitumen carriers that were set forth in greater detail in the preceding chapters.

Chapter G considers the possibilities of inorganic petroleum. Whereas the evidence of the organic origin of petroleum is direct, the geologic evidence supporting an inorganic origin is only indirect and not decisive.

The book is so full of ideas and the evidence adduced in support of them, that even this lengthy review does not give more than a fragmentary account of them. Despite the unorthodox conclusions that are expressed in places and the fact that at times they are established indirectly by argumentation rather than by means of direct evidence, the book is full of suggestions that are of value to students of petroleum genesis. I respective of the extent to which he may be willing to subscribe to the views of the author, the oil geologist will read the book with thoughtful interest.

JOSEPH T. SINGEWALD, JR.

THE JOHNS HOPKINS UNIVERSITY  
BALTIMORE, MARYLAND  
March 9, 1928

#### RECENT PUBLICATIONS

##### GENERAL

"Fossil and Recent Bryozoa of the Gulf of Mexico Region," by Ferdinand Canu and Ray S. Bassler. *Proceedings U. S. National Museum*, Washington, D. C., No. 2710, Vol. 72, Art. 14, pp. 1-199. 34 plates.

##### ILLINOIS

"Illinois Petroleum," *Press Bulletin Series No. 14, State Geological Survey, Urbana*. Contains report on "Structure and Oil Production of Eastern Clark County," by Gail F. Moulton and Jackson S. Young. Price, \$0.25.

##### OKLAHOMA

The following new reports may be obtained from the Oklahoma State Geological Survey, Norman, Oklahoma:

"Geology of Washington County," by Everett Carpenter. *Bulletin 40-V*. Price, \$0.30.

"Oklahoma Petroleum—An Industrial Survey," by Charles E. Bowles. *Bulletin 40-AA*. Price, \$0.30.

"Geology of Pawnee County," by Frank C. Greene. *Bulletin 40-CC*.  
Price, \$0.30.

"Physical Characteristics of the Arbuckle Limestone," by Charles E.  
Decker and Clifford A. Merritt. *Circular 15*. Price, \$0.30.

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THE ASSOCIATION LIBRARY

Headquarters acknowledges library accessions:

FRANCE

*From Pierre Viennott:*

*Le Gisement Pétrolifère de Gabian*



## THE ASSOCIATION ROUND TABLE

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### MEMBERSHIP APPLICATIONS APPROVED FOR PUBLICATION

The Executive Committee has approved for publication the names of the following applicants for membership in the Association. This does not constitute an election, but places the names before the membership at large. In case any member has information bearing on the qualifications of these applicants, please send it promptly to J. P. D. Hull, Business Manager, Box 1852, Tulsa, Oklahoma. (Names of sponsors are placed beneath the name of each applicant.)

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Art. R. May, F. E. Vaughan, E. F. Davis  
Frank R. Stockton, Taft, Calif.  
George M. Cunningham, R. C. Kerr, F. A. Davies  
James Marvin Weller, Urbana, Ill.  
M. M. Leighton, Gail F. Moulton, A. H. Bell

Arthur Karl Wilhelm, Bartlesville, Okla.

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J. V. Howell, C. Max Bauer, C. Don Hughes

Willard Weaver Rusk, Parco, Wyo.

J. S. Irwin, F. F. Hintze, Elfred Beck

THIRTEENTH ANNUAL MEETING OF THE AMERICAN ASSOCIATION OF PETROLEUM GEOLOGISTS, SAN FRANCISCO AND LOS ANGELES, CALIFORNIA, MARCH 21-25, 1928

The thirteenth annual meeting was called to order by President Gester, using the new silver-mounted gavel presented to the Association by President McCoy when he retired from office last year. Attendance at the technical sessions was characteristically large regardless of the toll taken by Mt. Tamalpais and the Golden Gate. Parenthetically, our press reputation of being the most sober-minded and business-attentive of all this country's countless conventions would be in real danger if we exposed ourselves every year to the tropic and exotic lure of California. To many of us a trip to the coast comes but once in a lifetime, so who would say that a business meeting is of greater importance than an unforgettable trip to the Muir Woods? Indeed, this charming touch of nature must have made all our minds akin, for the business sessions, if not largely attended, were marked by surprising unanimity. We cannot merely label this meeting as another successful convention. Perhaps the local committees do not realize what a full measure of enjoyment they provided, all the way from the personal welcome at the Ferry Building in San Francisco to the last plate of luscious fruit and basket of gay flowers complimenting the ladies at Los Angeles.

Although the meeting did not officially open until Wednesday, the arrival of the delegations from Colorado, Texas, Oklahoma, and Kansas on Monday gave an appearance of full activity at convention headquarters in the lobby of the Clift Hotel. The scientific program and technical exhibit were held in the Native Sons Auditorium a few steps from the hotel and continued through Wednesday, Thursday, and Friday. The general business committee, for the first time composed of elected representatives from geographic districts, met at the Clift, Tuesday night. The annual business meeting of the Association was held Thursday afternoon at the auditorium, following the nomination of officers on Wednesday afternoon.

The committee on geological studies, K. C. Heald, chairman, of the division of geology and geography of the National Research Council, met Tuesday morning. The Society of Economic Paleontologists and Mineralogists

held an all-day session on Thursday at the Clift. A joint meeting of the old and new executive committees was held Thursday morning.

The Society of Economic Paleontologists and Mineralogists elected the following officers: R. C. Moore, of Lawrence, Kansas, president; G. D. Hanna, of San Francisco, vice-president; F. B. Plummer, of Fort Worth, secretary-treasurer; and Joseph A. Cushman, of Sharon, Massachusetts, editor.

To provide organized amusement for visitors to two cities such as San Francisco and Los Angeles, naturally brimming with interest and wonder, seems like filling the cup of entertainment to overflowing, but this the California committees did. A dinner dance for all at the Fairmont Hotel, Thursday night, and for the ladies, tea and a fashion show at the Women's City Club, Wednesday, luncheon at Lakeside Country Club, Thursday, and visits to Gump's Jade and Crystal room and Chinatown shops on Friday, were the features at San Francisco.

On Saturday the curtain went up at Los Angeles and the convention headquarters flag appeared in the lobby of the Biltmore Hotel, where the J. Wallace Bostick golf trophy was also on display. A party of 125 or more was given an illuminating trip in parlor-car busses along the ocean shore and through the oil fields of the Los Angeles basin: Inglewood, a model field operated by the Standard; lunch at the beautiful La Venta Inn, Palos Verdes hills, overlooking the Pacific; Signal Hill, spectacular in topography and cores from depths of a mile and a half; and other fields and other sights.

And Saturday night,—dinner dance at the Mack Sennett studio! A full house and a surprise program that was different! Must be seen to be appreciated.

The golf tournament Sunday at the Riviera Country Club resulted as follows:

Member winner: Don Danvers, Corsicana, Texas

Score	Handicap	Net
87	19	68

Number participating—25

Guest winner: W. P. Winham, Bakersfield, California

80	10	70
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Number participating—5

Mr. Danver's name will be engraved on the J. Wallace Bostick golf trophy and Mr. Winham will receive one of the Bostick cups.

#### COMMITTEE ON ARRANGEMENTS

*General Committee.*—E. G. Gaylord, *chairman*; C. R. McCollom, *vice-chairman*; H. J. Hawley, *vice-chairman*; W. S. W. Kew, Joseph Jensen, J. T. Wood, S. H. Gester, Irving Augur.

*Entertainment.*—Irving Augur, *chairman*; A. A. Curtice, Jack M. Sickler, J. T. Wood, R. G. Whealton, T. L. Wark, E. J. Young.

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*Hotel*.—J. T. Wood, *chairman*; T. L. Wark, E. M. Butterworth, C. E. Meek, B. F. Hake.

*Program*.—W. S. W. Kew, *chairman*; Sidney Powers, Eliot Blackwelder, W. E. Wrather, H. A. Aurand, K. C. Heald, C. Max Bauer, E. Holman.

*Publicity and Exhibits*.—Joseph Jensen, *chairman*; V. L. King, Luther H. White, J. Elmer Thomas.

*Registration*.—S. H. Gester, *chairman*; R. P. McLaughlin, E. J. Young, Carl T. Long, T. J. Galbraith.

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*Women's Entertainment (Los Angeles)*.—Mrs. C. R. McCollom, Mrs. Irving Augur, Mrs. Walter A. English, Mrs. E. F. Davis, Mrs. Ward Blodgett, Mrs. Jack M. Sickler, Mrs. Ben K. Stroud, Mrs. H. S. Gale.

*Women's Entertainment (San Francisco)*.—Mrs. James T. Wood, Jr., *chairman*; Mrs. E. G. Gaylord, Mrs. S. H. Gester, Mrs. R. C. Stoner, Mrs. L. C. Decius, Mrs. G. O. Wilson, Mrs. Perham Harper, Mrs. R. G. Whealton, Mrs. Edwin Walter, Mrs. J. A. Taff, Mrs. W. S. W. Kew, Mrs. C. M. Wagner.

Special numbers on the technical program were the address of welcome by Mark L. Requa, an appeal by Waldemar Lindgren for the proposed abstract journal of the division of geology and geography of the National Research Council, and a paper by Harry R. Johnson on geological conditions at the recently collapsed St. Francis dam near Los Angeles.

## PAPERS

1. The California Oil Industry in 1927—AUSTIN CADLE
2. Recent Developments in Petroleum Research—K. C. HEALD
3. Notes on the Origin and Migration of Oil—JOHN L. RICH
4. Ceramics Applied to Petroleum Geology—ELFRED BECK
5. Progress Report Regarding Research Problem No. 5—Diatoms as a Source of Oil—C. F. TOLMAN, T. HASHIMOTO and L. A. THAYER
6. The Measurement of Flowage Pressures of Sedimentary Rocks and its Bearing on the Salt-Dome Problem—F. M. VAN TUYL
7. Compaction as a Cause of Migration of Petroleum—R. C. BECKSTROM and F. M. VAN TUYL
8. Limestones and Dolomites as Reservoir Rocks—W. V. HOWARD
9. Jamin Action—What It Is and How It Affects Production of Oil and Gas—STANLEY HEROLD
10. Notes on the Sedimentary Deposition of Petroleum—F. M. VAN TUYL and C. F. BARB
11. The Rôle of Bacteria in the Formation of Dark Sediments—F. M. VAN TUYL and QUENTIN D. SINGEWALD

12. Notes on Permian Sedimentation and Correlation—E. C. EDWARDS
13. The Use of Airplane Photographs in Geologic Work—WALTER A. ENGLISH
14. The Stratigraphy and Structure of the Cromwell Oil Field, Oklahoma—OLIVER C. GRAWE
15. Notes on the Stratigraphy of the Weatherford Area, Oklahoma—NOEL EVANS
16. The Subsurface Structure of Some Unsymmetrical Anticlines in the Rocky Mountains—JOHN G. BARTRAM and J. E. HUPP
17. The Relationship Between Over- and Under-Thrusting as Revealed by Experiments—THEODORE A. LINK
18. Some Structural Features of the East Side of the San Joaquin Valley, California—LEO S. FOX
19. Texas-Louisiana Gulf Coast Operations for 1927—CHARLES L. BAKER and M. VETTER
20. New Development in Southern California since 1923—JOSEPH JENSEN and GLENN D. ROBERTSON
21. Tectonics of the Valle Grande of California—BRUCE L. CLARK
22. The Monterey Shale—G. DALLAS HANNA
23. The Santa Monica Mountains, a Major Anticlinal Uplift Adjoining Los Angeles Basin—H. W. HOOTS
24. The Geology of the La Panza Quadrangle, San Luis Obispo County, California—RALPH ARNOLD and WAYNE LOEL
25. Ventura Avenue Oil Field, Ventura County, California—F. W. HERTEL
26. The Geology of the Seal Beach Oil Field—R. M. BARNES and W. W. COPP
27. An Ancient Shoreline and its Bearing on the Failure of an Oil Well—ARTHUR J. TIEJE
28. Recently Discovered Salt Domes of East Texas—B. COLEMAN RENICK
29. Comparative Results from the Use of Graphic and Loss Ratio Methods of Extrapolating Oil Well Decline Curves—ROSWELL H. JOHNSON and A. L. BOLLENS
30. The Position of Structure Among the Criteria for Oil Occurrence—FREDERICK G. CLAPP
31. Technical Papers and their Presentation—ARTHUR KNAPP

## PALEONTOLOGY AND MINERALOGY

1. Paleontologic Studies in the Upper Paleozoic—RAYMOND C. MOORE
2. Brackish-Water Pliocene Diatoms from the Kettleman Hills—G. DALLAS HANNA
3. A New Fauna from the Cook Mountain Eocene near Smithville, Bastrop County, Texas—W. ARMSTRONG PRICE and KATHERINE VAN WINKLE PALMER
4. Micropaleontologic Formational Divisions of the Upper Tertiary and Pleistocene of Southern California—G. H. DOANE and S. G. WISSLER
5. Additions to the List of Species Occurring in the Type Red Bluff, Gowanee, Mississippi—HENRY V. HOWE (Delivered by M. A. HANNA)
6. Notes on the Paleontology of the Santa Barbara Islands—LEO G. HERTLEIN

7. A Subsurface Study of the Richfield Oil Field, Orange County, California—STANLEY G. WISSLER and GEORGE C. KUFFEL
8. Some Notes on the Succession of the Marine Invertebrate Faunas of the Upper Fernando, Ventura County, California—EDWARD D. PRESSLAR
9. Notes on Miocene Paleontology and Stratigraphy of Colombia—F. M. ANDERSON

The total registration at the meeting was 387, classified as follows: (1) honorary member, 1, (2) active members, 212, (3) associate members, 49, (4) guests (women), 63, (5) guests (men), 62.

## MEMBERS REGISTERED AT THIRTEENTH ANNUAL MEETING

## HONORARY

Hill, Robert T., Los Angeles, Calif.

## ACTIVE

- |   |   |
|---|---|
| Anderson, Robert V., Menlo Park, Calif. | Augur, Irving, Los Angeles, Calif.              |
| Armstrong, J. M., Eastland, Texas       | Aurand, Harry A., Denver, Colo.                 |
| Arnold, Ralph, Los Angeles, Calif.      | Aurin, F. L., Ponca City, Okla.                 |
| Bailey, T. L., Ventura, Calif.          | Blackwelder, Eliot, Stanford University, Calif. |
| Baker, R. F., Houston, Texas            | Bohart, P. H., Tampico, Mexico                  |
| Barnes, R. M., Los Angeles, Calif.      | Bowes, Glenn H., Long Beach, Calif.             |
| Barrow, L. T., San Antonio, Texas       | Brace, O. L., Laredo, Texas                     |
| Bauer, C. Max, Amarillo, Texas          | Bremner, Carl St. J., Oxnard, Calif.            |
| Beal, Carl H., Los Angeles, Calif.      | Burton, George E., Ardmore, Okla.               |
| Beck, Elfred, Tulsa, Okla.              | Butterworth, E. M., Los Angeles, Calif.         |
| Benton, Louis B., Cisco, Texas          |   |
| Carlton, Dave P., Houston, Texas        | Classen, W. J., Menlo Park, Calif.              |
| Carson, C. M., Cupertino, Calif.        | Coffin, R. Clare, Denver, Colo.                 |
| Cashin, D. M., Houston, Texas           | Collingwood, D. M., Dallas, Texas               |
| Chase, J. L., Long Beach, Calif.        | Cunningham, George M., Bakersfield, Calif.      |
| Clark, B. L., Berkeley, Calif.          | Curtice, A. A., Los Angeles, Calif.             |
| Clark, Glenn C., Ponca City, Okla.      |   |
| Davies, F. A., Denver, Colo.            | Donoghue, David, Fort Worth, Texas              |
| Davis, Thornton, Wichita Falls, Texas   | Donovan, P. W., Minneapolis, Minn.              |
| Deussen, Alexander, Houston, Texas      | Driver, Herschel L., Glendale, Calif.           |
| Dolman, Phil B., San Angelo, Texas      | Duce, J. T., New York, N. Y.                    |
| Eaton, J. E., Los Angeles, Calif.       | Elliott, J. E., Los Angeles, Calif.             |
| Edwards, E. C., San Angelo, Texas       | English, Walter A., Los Angeles, Calif.         |
| Edwards, M. G., South Pasadena, Calif.  |   |
| Fath, A. E., San Angelo, Texas          | Fuqua, H. B., Fort Worth, Texas                 |
| Ferguson, John L., Amarillo, Texas      | Fyfe, Douglas, Los Angeles, Calif.              |
| Ferguson, R. N., Los Angeles, Calif.    |   |

Galbraith, T. J., San Francisco, Calif.  
 Gale, Hoyt Stoddard, Los Angeles, Calif.  
 Galloway, J. J., New York, N. Y.  
 Gardescu, Ionel I., Berkeley, Calif.  
 Gardiner, Chester M., Los Angeles, Calif.  
 Garrett, L. P., Houston, Texas  
 Gaylord, E. G., Berkeley, Calif.  
 Geis, Wilfred H., Los Angeles, Calif.  
 Gester, C. C., San Francisco, Calif.  
 Gester, S. H., San Francisco, Calif.  
 Giffin, Wilson C., Los Angeles, Calif.  
 Gillespie, Bartlett W., Inglewood, Calif.  
 Gish, Wesley G., Tulsa, Okla.  
 Goudkoff, P. P., Los Angeles, Calif.  
 Gould, Charles N., Norman, Okla.  
 Gray, Alfred, Dallas, Texas  
 Gulley, M. G., Ponca City, Okla.

Hagy, Lawrence R., Oklahoma City, Okla.  
 Hanna, G. D., San Francisco, Calif.  
 Hanna, Marcus A., Houston, Texas  
 Hares, C. J., Denver, Colo.  
 Harkness, Robert B., Toronto, Canada  
 Harrison, Thomas S., Denver, Colo.  
 Hawley, H. J., San Francisco, Calif.  
 Hazzard, Roy T., Shreveport, La.  
 Heald, K. C., Pittsburg, Pa.  
 Henny, G., Los Angeles, Calif.  
 Henson, G. R., Tulsa, Okla.  
 Herold, Stanley C., Stanford University  
 Calif.  
 Herrick, Henry N., San Francisco, Calif.  
 Hertel, F. W., Ventura, Calif.  
 Hinds, N. E. A., Berkeley, Calif.  
 Holland, L. F. S., Hollywood, Calif.  
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 Hudson, F. S., Los Angeles, Calif.  
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 Hughes, Richard, Tulsa, Okla.  
 Hull, J. P. D., Tulsa, Okla.  
 Hyde, C. E., Fort Worth, Texas

Ickes, E. L., Los Angeles, Calif.

Jensen, Joseph, San Francisco, Calif.  
 Johnson, Harry R., Los Angeles, Calif.  
 Johnston, D. M., San Francisco, Calif.  
 Jones, Boone, Cushing, Okla.  
 Jones, Coy B., San Angelo, Texas  
 Justice, P. S., Beaumont, Texas  
 Keeler, W. W., Tulsa, Okla.  
 Keppler, L. G., Tulsa, Okla.  
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 Kraus, Edgar, San Angelo, Texas  
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 Lee, Marvin, Wichita, Kan.  
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 Levorsen, A. I., Tulsa, Okla.  
 Link, Theo. A., Calgary, Alta., Canada  
 Loel, Wayne, Los Angeles, Calif.  
 Longyear, Robert D., Minneapolis, Minn.  
 Luman, E. D., Tulsa, Okla.  
 Lynton, Edward D., Los Angeles, Calif.  
 Lyons, Richard T., Tulsa, Okla.

MacDonald, E. H., Billings, Mont.  
 Macready, George A., Los Angeles, Calif.  
 Martin, F. O., Los Angeles, Calif.  
 Martin, George C., Washington, D. C.  
 May, A. R., Bakersfield, Calif.  
 McCollom, C. R., Los Angeles, Calif.  
 McCoy, Alex W., Ponca City, Okla.  
 McFarland, R. S., Tulsa, Okla.  
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 McLaughlin, R. P., Los Angeles, Calif.  
 McLeod, Angus, Dallas, Texas  
 Meek, Charles E., Berkeley, Calif.  
 Metcalf, R. J., Fort Worth, Texas  
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 Monnett, V. E., Norman, Okla.  
 Moody, Graham B., Colorado, Texas  
 Moore, Raymond C., Lawrence, Kan.  
 Moran, Robert, Los Angeles, Calif.  
 Myers, Desaix B., Pasadena, Calif.

Nicholls, William M., Wichita Falls, Tex,

- Officer, H. G., Tulsa, Okla.  
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- Palmer, Robert H., Seattle, Wash.  
 Paulsen, Jasper W., Jr., Los Angeles, Calif.
- Radler, Dollie, Tulsa, Okla.  
 Reed, R. D., Los Angeles, Calif..  
 Rennie, W. E., Denver, Colo.  
 Rettger, R. E., San Angelo, Texas  
 Rich, John L., Ottawa, Kan.  
 Riggs, R. J., Bartlesville, Okla.
- Sawtelle, George, San Angelo, Texas  
 Severy, C. L., Tulsa, Okla.  
 Sherry, William J., Tulsa, Okla.  
 Show, Joseph H., Coalinga, Calif.  
 Sickler, Jack M., Pasadena, Calif.  
 Singewald, Quentin D., Golden, Colo.  
 Snider, L. C., New York, N. Y.  
 Snow, R. D., Tulsa, Okla.  
 Soper, E. K., Los Angeles, Calif.  
 Soyster, Merwin H., Whittier, Calif.  
 Stalder, Walter, San Francisco, Calif.
- Taliaferro, N. L., Berkeley, Calif.  
 Taylor, Charles H., Oklahoma City, Ok.  
 Thomas, C. R., Eldorado, Kan.  
 Tieje, A. J., Los Angeles, Calif.
- Orynski, Leonard W., Colorado, Texas  
 Osborne, Clarence, Los Angeles, Calif.
- Pemberton, J. R., Beverly Hills, Calif.  
 Petsch, A. H., Lexington, Mo.  
 Pratt, Wallace E., Houston, Texas
- Roberts, John R., San Francisco, Calif.  
 Robertson, Glenn D., Los Angeles, Calif.  
 Robinson, Heath M., Dallas, Texas  
 Row, Charles H., San Antonio, Texas  
 Ruby, Glen M., Edmonton, Alta., Can.
- Starke, Eric A., Los Angeles, Calif.  
 Steinmayer, R. A., New Orleans, La.  
 Stevens, G. R., Shreveport, La.  
 Stewart, Hugh A., Denver, Colo.  
 Stewart, Irvine E., Los Angeles, Calif.  
 Stewart, R. E., Los Angeles, Calif.  
 Storm, Willis, Dallas, Texas  
 Stroud, Ben K., Los Angeles, Calif.  
 Suman, George, Bakersfield, Calif.  
 Suverkrop, Lew, Taft, Calif.
- Trask, Parker D., La Jolla, Calif.  
 Trowbridge, A. C., Iowa City, Iowa  
 Truex, A. F., Tulsa, Okla.  
 Turman, A. F., San Francisco, Calif.
- Uren, L. C., Berkeley, Calif.
- Van Tuyl, F. M., Golden, Colo.  
 Vaughan, F. E., Los Angeles, Calif.  
 Vetter, John M., Houston, Texas
- Vickery, F. P., Glendale, Calif.  
 Vorbe, Georges, Midland, Texas  
 Vorck, Charles R., Denver, Colo.
- Wagner, C. M., Los Angeles, Calif.  
 Wagy, Earl W., Berkeley, Calif.  
 Walker, W. L., Bartlesville, Okla.  
 Warren, Van Court, Los Angeles, Calif.  
 Wasson, Theron, Chicago, Ill.  
 Weaver, Paul, Houston, Texas  
 Weinzierl, John F., Houston, Texas  
 Weinzierl, Mrs. Laura L., Houston, Tex.  
 Weirich, T. E., Tulsa, Okla.
- Wheeler, O. C., Stanford, Calif.  
 White, Luther H., Tulsa, Okla.  
 Whitwell, E. V., Calgary, Alta., Canada  
 Wilson, W. B., Tulsa, Okla.  
 Whisenant, J. B., Big Springs, Texas  
 Wissler, Stanley G., Los Angeles, Calif.  
 Witt, Herbert N., San Francisco, Calif.  
 Wood, J. T., Jr., San Francisco, Calif.

Young, E. J., San Francisco, Calif.

#### ASSOCIATE

- Barlow, Victor, Los Angeles, Calif.      Bowen, Lot, Bakersfield, Calif.

Cadle, Austin, Sausalito, Calif.  
 Carsey, J. Ben, McCamey, Tex.  
 Clark, Leslie M., Bakersfield, Calif.

Corby, Grant W., Los Angeles, Calif.  
 Crandall, K. H., Colorado, Texas  
 Crandall, Richard R., Los Angeles, Calif.

Danvers, Don, Corsicana, Texas  
 Davies, H. F., Denver, Colo.  
 DeFord, R. K., Amarillo, Texas

Doane, G. H., Los Angeles, Calif.  
 Doolittle, J. J., San Francisco, Calif.  
 Dorrance, J. R., Bakersfield, Calif.

Emch, John W., San Angelo, Texas

Evans, Frank, Jr., San Antonio, Texas

Fahmy, E. H., Long Beach, Calif.  
 Fitts, John, Ada, Okla.

Fox, Leo S., Los Angeles, Calif.

Galloway, Alan J., Bakersfield, Calif.

Gardiner, T. M., Jr., Bakersfield, Calif.

Hardy, Norman, Los Angeles, Calif.  
 Hazzard, A. M., Oilfields, Fresno County, Calif.

Hoots, H. W., Pasadena, Calif.  
 Hunt, Edwin H., Cody, Wyo.  
 Hurndall, John P., Bakersfield, Calif.

James, W. E., Los Angeles, Calif.

Kirby, J. M., Ventura, Calif.

LaRue, J. E., Houston, Texas  
 Lavington, Charles S., Denver, Colo.

Lebkicher, Roy, Denver, Colo.  
 Longnecker, O. M., Jr., Houston, Texas

Miller, E. F., Tulsa, Okla.

Parks, Ernest K., Berkeley, Calif.

Pettigrew, Virgil, Wichita Falls, Texas

Rankin, Wilbur D., Glendale, Calif.  
 Rolshausen, F. W., Houston, Texas

Rusk, W. W., Parco, Wyo.  
 Russell, R. Dana, South Pasadena, Calif.

Seitz, J. R., Wichita Falls, Texas  
 Senftleben, G. G., Tulsa, Okla.

Smith, George, Bakersfield, Calif.  
 Strader, Harold L., Cheyenne, Wyo.

Waterfall, L. N., Glendale, Calif.  
 Webster, H. B., Oakland, Calif.  
 Weeks, H. J., Dallas, Texas

Whealon, R. G., Taft, Calif.  
 Winterer, E. F., Berkeley, Calif.  
 Woods, E. Hazen, San Angelo, Texas

THIRTEENTH ANNUAL BUSINESS MEETING  
 NATIVE SONS AUDITORIUM, SAN FRANCISCO, CALIFORNIA  
 MARCH 22, 1928

G. C. GESTER, *presiding*

President Gester called the meeting to order at 4:20 P. M.

Members present about 60.

Minutes of the twelfth annual meeting were read by secretary Donoghue and approved by the chair.

President Gester read his annual report.

## REPORT OF THE PRESIDENT

*Members of the American Association of Petroleum Geologists and Guests:* It is perhaps appropriate, before reporting to you upon the activities of your Association during the past year, to bring to your attention the fact that the meeting here assembled in San Francisco is not strictly a San Francisco convention. It is a California convention, and to your membership in California should go the credit for its success.

California has been, is, and for many years will continue to be, a great oil-producing state, probably one of the largest producers in the United States, and it is therefore fitting that we should be honored with a meeting of the American Association of Petroleum Geologists. From the days of '49 California has been a mecca for the pioneers. Geologists are pioneers in the oil industry. What, then, could be more appropriate than our convening here?

We are, however, a long way from the center of the main body of our membership, and I wish to express my appreciation and gratitude to those of you who have come from afar and I should like to say in behalf of all of you, "Here's a toast to our absent members." We all know that their thoughts are with us and that they are relying upon us to continue the good work of improving and strengthening our organization that we may be better fitted to aid the oil industry and to serve the public at large.

In some respects the past year has been a trying one for the petroleum industry. The over-production of oil has been great and prices have been low. Compared to prices received for petroleum and its by-products, costs have been high and loud has been the cry of "Waste, waste." Such cries are much like the old story of the shepherd boy who cried, "Wolf, wolf." True, there has been some waste, but this applies to gas more than to oil, and compared to the total efficiently used output, such waste has been small. And what great industry carries on its work without some waste? Also, who are more keenly interested in the prevention of waste and in promoting the efficient utilization of all products and by-products than the owners and operators of that industry? Furthermore, who are more vitally interested in the efficient conservation of the raw materials than the owners and operators? The greed for an immediate gain or quick realization of profits by some land-owners and some operators, both large and small, has occasionally clouded the issue, but usually not for long.

During the past year on account of the great over-production the petroleum industry has done much to accelerate the work that has been going on for years in matters of conservation. I shall not attempt to discuss this subject here. We are all familiar with the splendid work that the American Petroleum Institute has been doing along these lines, and I think we are justified in feeling a sense of pride in the fact that there were many of our Association's members who aided in the conservation work of the American Petroleum Institute, and who have been, and still are, materially aiding in the scientific and practical study of conservation of oil and gas.

There is no doubt that the studies in the conservation of oil and gas are bearing fruit. The geologist, aided in no small degree by the drill that can penetrate to depths of more than 8,000 feet, has been constantly adding to our

known reserves. While such reserves cannot last forever, there is more oil in sight that is proven, and it is under better control to-day than ever before. We can, by forecasting a continued improvement in geological methods and in conservation practice, see an adequate supply of crude petroleum extending farther into the future than at any time in the past. A controlled abundance of oil and gas means a stabilized petroleum industry and the American Association of Petroleum Geologists, collectively and through its members, can do its share in the continued increasing of the crude supply and aiding in means for its efficient conservation.

This is the thirteenth regular annual meeting of the Association. The first two meetings were held under the name of the Southwestern Association of Petroleum Geologists, but during 1917 the value of such an organization of at least national extent became so apparent to its organizers that at the annual meeting in Oklahoma City, February 15 and 16, 1918, the name was changed to "American" in place of "Southwestern" and a new constitution was adopted. In May, 1917, there were 87 regular members and 7 associate members. There are now 1,952 members, divided as follows: 1,282 active members and 664 associate members.

*Bulletin.* Coincident with the growth of the membership of the Association, has been that of the *Bulletin* of the Association. From a comparatively small yearly *Bulletin*, it has developed into a monthly publication, and is to be found distributed in all parts of the United States where oil geologists are working or training, as well as in most of the oil districts of the world. Your *Bulletin* is the official voice of the Association. Its splendid growth is due to the fact that the information which it carries is authentic. Its publication as a high-class scientific magazine has been, and should continue to be, one of the important activities of the Association. Further, let me urge that an aggressive policy be continued in the development and in the wider distribution of your *Bulletin*.

During the past year your executive committee has arranged that the printing of the *Bulletin* be done in Tulsa by The Mid-West Printing Company, Tulsa, Oklahoma, in place of the University of Chicago Press, Chicago, Ill. The work of the University Press was of the highest order and we have no complaints to make. The move was made to facilitate the work of your business manager and editorial staff, with headquarters at Tulsa, in the handling of the numerous details incident to the publication of such a magazine. Such a change makes possible a material reduction in time between the submission of manuscripts and their final publication. This is important in the case of timely articles, which lose much of their value if publication is too long delayed. It is expected that the cost of publishing in Tulsa will be approximately the same as it was in Chicago, and it is possible that a small monetary saving may be made. The change took place January 1 and you will notice that the workmanship and material are equal to the high standard set by the University of Chicago Press.

In addition to your regular monthly *Bulletin*, the Association has, during the past year, prepared and published an index to Volumes 1 to 10. This is more topical and more detailed than the short index in each year's volume. We have also completed the publication of the symposium entitled *Theory of Continental Drift*. This is the first of our publications handled under the

new revolving publication fund, which will be mentioned later. Furthermore, *Structure of Typical American Oil Fields*, Volume 1, is now ready for the printer and Volume 2 is to be published as soon as the promised papers and data materialize.

*Revolving publication fund.*—In 1926 a mid-year meeting was held in New York City. A part of the funds which were raised to defray the expenses of this meeting were not used. At the suggestion of Mr. E. L. DeGolyer the New York committee donated this money, approximately \$4,000.00, to the Association, first, for the purpose of providing for the expense of publishing the papers on *Theory of Continental Drift*, many of which were given at the New York meeting, and second, for the establishing of a revolving publication fund. This fund is to be used by the Association for publications other than the *Bulletin*. Your executive committee, in conjunction with Mr. DeGolyer, who represents the New York committee, have arranged an agreement and plan which we hope will perpetuate this fund and give your Association the nucleus of a fund which may be used to defray the cost of other scientific publications, such as *Structure of Typical American Oil Fields*.

*Finances.*—The judgment of last year's officers in relieving the Tulsa Geological Society of responsibility for a possible deficit in the Association seems entirely justified, inasmuch as our statement of December 31, 1927, shows \$2,100.00 in our principal checking account after deducting all unpaid 1927 accounts. This is exclusive of any 1928 dues, of the time investments amounting to about \$17,000.00, and is exclusive of the revolving publication fund, which amounts to approximately \$4,000.00.

In accordance with action taken by the Association at the annual meeting in 1919, your executive committee ordered an audit of our accounts made as of December 31, 1927. The Association's business, including the expenses of the *Bulletin* and the receipts of dues, has heretofore been handled by calendar year, therefore an audit as of the calendar year more clearly shows the Association's financial condition. Mr. Donoghue, your secretary-treasurer, will give you a full statement of our financial condition as of the first of the year. He will also present a statement as of the first of March, which is simply for comparison with last year's March audit.

*Corporation matters.*—This year completed the unfinished business relating to the incorporation of the Association. Mr. Max W. Ball and Dr. Charles E. Decker, respectively president and secretary of the unincorporated organization of April 15, 1924, have assigned and conveyed all properties and effects of the unincorporated Association to the corporate body. All matters relating to federal and local taxation of the incorporated body have been attended to. Insurance has been taken out covering printed stock and office equipment. Furthermore, a record of all corporate matters, of executive meetings and of business association meetings, has been started. There have also been included in this record as many of the records of past activities of the Association as could be found. This includes copies of the constitution and by-laws and all changes and additions to same that have been made to date. Since we are now an incorporated, growing organization, it seemed advisable to your executive committee that such a record be started, and it is our recommendation that it be continued.

*Organization of new business committee.*—At the annual meeting in Tulsa March 20, 1927, your executive committee was instructed to add a new section to the by-laws providing for a general business committee, to be elected by members of various districts in local meetings (districts to be decided upon by the executive committee); number of delegates elected from each district to be determined by the number of full members residing in said district; term of office to extend over a three-year period, one-third of the members retiring each year; in case a district failed to elect representatives, the same to be elected by the executive committee thirty days before the annual meeting. This general business committee is to act as a council for the Association and as an advisory body to the executive committee.

In accordance with these instructions, a new section of the by-laws has been prepared, and in accordance with the provisions therein set forth, your general business committee was elected, a chairman appointed, and their recommendations will be submitted to you in the course of regular business.

*New headquarters.*—In December, 1927, the Association headquarters were moved from the Tulsa Public Library Building to a small but comfortable suite of rooms in the Chamber of Commerce Building. The space allotted us is, for the present, adequate for our needs, and we are very appreciative of the fact that this office space is guaranteed free of cost to us until July, 1929. With only a little more than a year's time remaining during which free office space has been provided, we should this year begin to anticipate our needs for more space and the possibility of having to pay rent, which would exceed annually the little surplus which we accumulated this last year by means of strict economy.

The time is also not far distant when we shall have need of room for a library. We are slowly accumulating scientific works and pamphlets, so far at no expense to the Association. These are chiefly from exchange, and editorial copies. The total number of volumes and pamphlets probably exceeds 1,000. I believe that a good library would be an asset to our Association headquarters, but to have a library of any value we would need to have not only the additional space, but the additional cost of a librarian.

*Research.*—It has been recognized since the earliest days of our Association that we should sponsor and promote the cause of research of petroleum geology. Your Constitution states as one of its objects, "to foster the spirit of scientific research among its members." Much of the work which a geologist does may, in the broad sense, be classed as research and through the many articles which have appeared in our *Bulletin*, we have fostered the spirit of scientific research among our members.

How successfully we have attained this object, in so far as our efforts have served the petroleum industry, is indicated in the report of the American Petroleum Institute technical committee appointed to determine the need of organizing technical talent under the supervision of the Institute. The committee reported that only in *one* of the several scientific or technical divisions of the work were the needs of the industry being fully and satisfactorily met by an existing organization. That one technical division mentioned was petroleum geology, and that one organization, the American Association of Petroleum Geologists.

Notwithstanding this signal recognition, however, it may be said that outside of the articles published in our *Bulletin*, and the activities of some of our members individually, the Association has not accomplished much of a definite and outstanding character along the line of research. Mr. Alex McCoy, a strong advocate of research, stated in his presidential report to you last year that "Research can only be promulgated by an accumulation of a great many well-correlated and catalogued facts followed by careful scientific analysis of them." Now, the executive committee realized that the Association did not have the facilities to carry on systematic compilation or experimental work. Furthermore, it is hardly worth while to attempt such work in a disorganized manner, and work of this nature by individuals, or small groups, is handicapped by the limitation of known facts. On the other hand, the executive committee considered that there are many facts available for the records of the Association by the summation of knowledge held individually throughout its ranks. Therefore, we have suggested a definite move to present these facts to the Association by a series of symposiums on the more important problems of petroleum geology.

A good example of this type of scientific research is that of the work which was started last year in the symposium on the relation of petroleum accumulation to structure. Here was a splendid opportunity to produce something definite in the way of scientific research. I think that many of us have been dilatory in taking advantage of this opportunity. To date, we have received less than half of the material necessary to complete a creditable work on this subject. Considerable very good material, however, has been gotten together, consisting of approximately 600 manuscript pages. This material should not be withheld from publication too long, and it seems advisable to publish the work in two volumes. We have the opportunity of publishing a very creditable and useful book on this subject, but in order to complete the picture we must first have all of the available data assembled and then a critical analysis made of the assembled data by competent geologists.

I feel sure that some very enlightening facts may be brought out from such an analysis, so let me urge that those of you who have promised papers and those of you who have not promised papers but who have material which would be pertinent to this subject, submit such papers or data as soon as possible. We have started a good work. Let us not leave it half finished!

Your executive committee has given considerable thought to the Association's activities in research matters, and it is our wish that this subject be open for discussion at this business meeting, in order that an expression of your opinion may be had as a guide for your executive committee and your committee on research.

Your present research committee was established and appointed by authorization of your executive committee in March, 1923, and was composed of: W. E. Wrather, chairman; Max W. Ball, Carl H. Beal, E. L. DeGolyer, James H. Gardner, G. C. Gester, Wallace E. Pratt, W. A. J. M. van der Gracht and Chester W. Washburne. The personnel of this committee has not been changed. In our *Bulletin*, Volume 11, No. 6 (June, 1927), Mr. Wrather published a report of progress of the research committee. This included a brief statement of the research personnel, works and objects of our Association, the central petro-

leum committee of the American Petroleum Institute and the National Research Council. The relationship of the American Association of Petroleum Geologists to the American Petroleum Institute's central petroleum committee and the committee on studies in petroleum geology of the National Research Council, is that of coöperation and close unofficial contact through geological members. Three of the nine members of the American Petroleum Institute's central committee are geologists. At present, they are all members of our Association. All of the eleven members of the National Research Council's committee on studies of petroleum geology are also members of the Association. Furthermore, your Association is entitled to two members on the division of geology and geography of the National Research Council. These are appointed by your president for a period of three years and are not eligible to reappointment. The present representatives are Sidney Powers, who was appointed last year, and W. H. Twenhofel, whose term expires June 30, 1928. In accordance with the request from Doctor Lindgren, chairman of the division of geology and geography, I took pleasure in nominating Mr. Alex W. McCoy to succeed Doctor Twenhofel.

Mr. W. E. Wrather, as chairman of our research committee, has given much thought and time to the subject of research and he considers it advisable that we should, if possible, strengthen our organization and method of handling research matters. A permanent committee, such as we have, has some advantages. On the other hand, "a new broom sweeps clean." Might it not, therefore, be advisable that, in place of a permanent committee, it be made a duty of your executive committee to appoint a new research committee, consisting of nine members whose term of office shall be three years excepting that one-third of those appointed the first year shall serve for one year only and one-third for two years only, thus providing that one-third of the membership shall be appointed each year. The majority of the members of such committee, moreover, should be so located that they can occasionally get together without undue expense and time. On account of our widely scattered membership, it might be advisable to have sectional sub-committees.

A committee without definite duties, or program, rarely does very much. Therefore, certain responsibilities should be placed on the committee, for example, the assembling of the papers necessary for a symposium, the analysis of such assembled data or the appointment of geologists capable of doing that work and seeing that it is done. In the past, such work has devolved upon the shoulders of two or three of our members whom you all know, and it is unfair to place the burden of such responsibilities upon so few. Another responsibility is the outlining of definite research problems in petroleum geology to be handled by the Association or its members, or of recommending such research projects to outside organizations such as the American Petroleum Institute, the National Research Council, the Smithsonian Institution, and universities capable of doing such work. Definite, well-thought-out projects of this kind will, I am sure, be given careful consideration by the National Research Council and will be appreciated by that organization. There is no body of men more capable of formulating such research problems than you are. The opportunity is open. Let us take advantage of it.

Before closing, I wish to take this opportunity to express my appreciation of the whole-hearted coöperation given to Association affairs by the other

members of the executive committee and by the regional directors and editors. May I also commend to you the good work of our headquarters staff, who, under the leadership of our business manager, Mr. Hull, have served the Association faithfully and well during the past year. Thanks are also due to each and every one of the members of the committees who have given freely of their time in the preparation for the California Convention. Also, thanks are due to the oil companies and affiliated interests that rendered us financial assistance.

Many of our members have, throughout the year, shown their interest and loyalty to the Association by advice, suggestions and criticisms, all of which have been much appreciated. It is this type of interest and cooperation which has done much to stimulate the growth and worth of our Association and I know of no other similar organization having a finer spirit of comradeship; it has, on my part, been an honor and a pleasure to have had the privilege of serving you as your president.

G. C. GESTER

The president was given a rising vote of appreciation.

Secretary-treasurer Donoghue presented his annual reports.

#### REPORT OF THE SECRETARY

This report is prepared for comparison with last year's report as published on pages 541 and 542, Vol. 11, No. 5, of the *Bulletin* (May, 1927). The geographic distribution of members in 1927 was published on page 317, Vol. 11, No. 3, of the *Bulletin* (March, 1927). The list of members as of March 1, 1928, was published on pages 295-338, Vol. 12, No. 3, of the *Bulletin* (March, 1928).

Seven members died since the last annual meeting and memorials have been published in the *Bulletin*: Noah C. Adams, Conrad K. Bontz, John W. McKim, E. G. Sinclair, Stuart Weller, I. C. White, and C. Edwin Whiteside.

Our increase in membership for the period, March 1, 1927, to March 1, 1928, is 282, the largest annual increase in the history of the Association. Our membership is now 1,952.

#### Membership of the Association:

Number of members May 19, 1917 (first published list) . . . . .	94
Number of members February 15, 1918 . . . . .	176
Number of members March 15, 1919 . . . . .	210
Number of members March 18, 1920 . . . . .	392
Number of members March 15, 1921 . . . . .	621
Number of members March 8, 1922 . . . . .	767
Number of members March 20, 1923 . . . . .	901
Number of members March 20, 1924 . . . . .	1,080
Number of members March 21, 1925 . . . . .	1,253
Number of members March 20, 1926 . . . . .	1,504
Number of members March 1, 1927 . . . . .	1,670
Number of honorary members March 1, 1928 . . . . .	6
Number of active members March 1, 1928 . . . . .	1,282
Number of associate members March 1, 1928 . . . . .	664
Total number of members, March 1, 1928 . . . . .	1,952

# THE ASSOCIATION ROUND TABLE

585

Increase in membership since March 1, 1927 .....	282
Applicants elected, dues unpaid .....	41
Applicants approved for publication .....	88
Recent applications .....	65
Total applications on hand .....	194
Applications for transfer approved for publication .....	44
Recent applications for transfer .....	42
Total applications for transfer on hand .....	86
Number of members withdrawn .....	20
Number of members dropped .....	30
Number of members died .....	7
Total loss in membership .....	57
Number of members in arrears, 1927-28 dues .....	44
Active members in arrears, 1928 dues .....	420
Associate members in arrears, 1928 dues .....	244
Total number of members in arrears, 1928 dues .....	664

## Circulation of the Bulletin:

1. Subscriptions (non-members)	
Libraries (domestic, 101; foreign, 21) .....	123
Companies (domestic, 45; foreign, 36) .....	81
Individuals (domestic, 54; foreign, 26) .....	80
Total non-member subscribers .....	284
2. Exchanges, etc. ....	57
3. Association members .....	1,952
Total monthly circulation of <i>Bulletin</i> .....	2,293

## Geographic Distribution of A. A. P. G. Members:

In March, 1928, the members of the Association numbered 1,952, situated in 41 states and 29 foreign countries.

### UNITED STATES

Texas .....	575	Kansas .....	57	Arkansas .....	12
Oklahoma .....	455	Pennsylvania .....	47	Wyoming .....	12
California .....	238	Illinois .....	23	Kentucky .....	10
Colorado .....	70	Missouri .....	23	Ohio .....	9
New York .....	70	Washington, D. C. .....	19	Minnesota .....	7
Louisiana .....	59	New Mexico .....	14	Montana .....	7

## THE ASSOCIATION ROUND TABLE

Connecticut . . . . .	6	New Jersey . . . . .	3	Indiana . . . . .	1
Massachusetts . . . . .	6	Virginia . . . . .	3	Nevada . . . . .	1
West Virginia . . . . .	6	Iowa . . . . .	2	North Carolina . . . . .	1
Maryland . . . . .	5	Michigan . . . . .	2	South Dakota . . . . .	1
Arizona . . . . .	4	Oregon . . . . .	2	Utah . . . . .	1
Mississippi . . . . .	4	Tennessee . . . . .	2		
Washington . . . . .	4	Wisconsin . . . . .	2		
Alabama . . . . .	3	Georgia . . . . .	1	Total United	
Nebraska . . . . .	3	Florida . . . . .	1	States . . . . .	1,771

## FOREIGN

Mexico . . . . .	41	Switzerland . . . . .	4	Dominica . . . . .	1
Venezuela . . . . .	34	Trinidad . . . . .	4	Ecuador . . . . .	1
Canada . . . . .	13	Australia . . . . .	2	India . . . . .	1
England . . . . .	10	Bolivia . . . . .	2	Java . . . . .	1
Holland . . . . .	9	British Borneo . . . . .	2	New Zealand . . . . .	1
Argentina . . . . .	8	Dutch Borneo . . . . .	2	Nova Scotia . . . . .	1
Colombia . . . . .	8	Germany . . . . .	2	U. S. Soviet	
France . . . . .	4	Scotland . . . . .	2	Republics . . . . .	1
Japan . . . . .	4	Sumatra . . . . .	2		
Peru . . . . .	4	British Guiana . . . . .	1	Total Foreign . . . . .	170
Roumania . . . . .	4	Chile . . . . .	1		

Address unknown . . . . . 11

Grand Total . . . . . 1,952

DAVID DONOGHUE, *Secretary*

## REPORT OF THE TREASURER

The report of the treasurer showing the financial condition of the Association as of December 21, 1927, and the auditor's statement were published on pages 286-91, Vol. 12, No. 3, of the *Bulletin* (March, 1928). The report showed \$9,516.46 in general checking accounts, \$17,740.88 in investments and savings accounts, and \$4,124.72 in the publication fund, or a total of \$31,382.06 in the treasury. After deducting the amount of unpaid bills chargeable to 1927 accounts, and the amount received in advance for 1928 dues, and exclusive of investments and the publication fund, there remained in the checking account approximately \$2,100.00. Last year, the comparable surplus was \$900.00.

Heretofore, our annual reports have shown the condition of the treasury in March; hereafter, these reports will be as of December 31, inasmuch as the Association year now corresponds with the calendar year. It is worth noticing here, however, the financial development of Association business during the old fiscal year just ending. The monthly financial report of the business manager to the executive committee, as of March 1, 1928, prepared for comparison with the treasurer's report as of March 10, 1927, one year ago, shows the following outstanding items (the figures refer to our principal checking account for a full year ending in March, 1927 and 1928, respectively, exclusive of the investments and the publication fund):

	1927	1928
Cash on hand March 10, 1927 . . .	\$11,929.01	March 1, 1928 . . . \$16,857.44
Receipts from dues . . . . .	21,116.75	25,477.75
Bulletin subscriptions and sale (including Index) . . . . .	8,421.86	10,219.63
Receipts from Salt Dome volumes . .	2,725.17	1,323.33
Advertising receipts . . . . .	1,586.70	2,860.22
Total receipts for period . . . . .	34,751.26	41,372.77
Total funds handled . . . . .	43,960.44	53,301.78
Total Bulletin expense (including Index) . . . . .	17,310.05	21,625.58
General office expense (salaries, supplies, etc.) . . . . .	9,673.46	14,562.75
Total disbursements . . . . .	31,880.12	46,494.54

On March 10, 1927, the total amount of all Association funds on hand in cash and securities was \$29,810.54; on March 1, 1928, the corresponding total was \$38,813.86.

DAVID DONOGHUE, *Treasurer*

Editor Rich presented his annual report.

#### REPORT OF THE EDITOR

The past year has witnessed no important change in editorial policy. A few minor changes in the make-up of the *Bulletin* have been made, of which the most important was a change back to the original width of printing on the page. During the year the printing of the *Bulletin* has been transferred from Chicago to Tulsa. This makes possible considerable saving of time between the receipt of a manuscript and its final publication and a saving of expense formerly required for correspondence, postage, and telegrams. The change has been made without affecting the make-up or appearance of the *Bulletin*.

Special publications issued during the year were: (1) *Index to Volumes I-X*, (2) *Theory of Continental Drift*. The results of last year's symposium are to be issued in two volumes. Of these, *Structure of Typical American Oil Fields*, Volume 1, is now ready for the printer. Volume 2 is awaiting completion of certain promised papers and is expected to appear late in 1928.

The ten-volume index is more detailed than the previous index, and should prove an indispensable part of the equipment of every geologist.

The *Theory of Continental Drift* is a significant contribution. Irrespective of the merits of the theory itself, the discussions which it has provoked; the broad range of the papers, touching almost every angle of fundamental geological science; and the discussions by leading authorities of the basic causes of earth structures, make this volume one of the most interesting and stimulating which has recently appeared and one which a geologist, particularly if he is located outside of the centers of the most active geological discussion, cannot well afford to miss.

*Structure of Typical American Oil Fields* should prove a mine of source material on which further advances of the science of geology as applied to

petroleum may be built. Some of the papers have already appeared in the *Bulletin*, but many of them will be published for the first time in the book.

Of the Salt Dome volume only about 300 copies remain. This book has proved the value of special publication of material gathered by the Association. It has also been a source of considerable revenue to the Association.

The revolving publication fund, details of which have been announced by your president, affords a means by which the Association may from time to time make public some of the mass of information on special topics available in scattered form among its members. It is possible that one of the greatest contributions which the Association could make to its science might be through the publication by this fund of symposia on various vital topics.

In conclusion, I wish to make acknowledgment of the efficient work of Mr. Hull and Miss Heath in carrying on the detailed and arduous work of editing and preparing the *Bulletin* for publication, and to express to the regional associate editors the appreciation of both Mr. Hull and myself for their loyal assistance.

JOHN L. RICH, *Editor*

Wallace Pratt read the report of the resolutions committee.

#### REPORT OF THE RESOLUTIONS COMMITTEE

*Be it resolved*, that the American Association of Petroleum Geologists assembled in their Thirteenth Annual Convention at San Francisco and Los Angeles, California, extend to the members of the Pacific Section of the Association; the San Francisco Chamber of Commerce; San Francisco Convention and Tourist League; Los Angeles Chamber of Commerce; Chamber of Mines and Oil; the oil companies and the supply companies contributing to the meeting; the ladies of the two cities; and the Clift Hotel, as well as the numerous committees, most cordial appreciation of the hospitality and efforts put forward for the success of the meeting.

*Be it further resolved*, that a copy of this resolution be spread upon the minutes of this meeting.

*Be it resolved*, that whereas Dr. I. C. White, state geologist of West Virginia for the last thirty years, the father of the anticlinal theory and an honorary member of this Association, died on November 25, 1927, therefore we do reaffirm our great esteem for and appreciation of his contribution to petroleum geology, and that we do hereby express our deepest regret at his death.

*Be it further resolved*, that a copy of this resolution be spread upon the minutes of this meeting, and that the president be requested to forward a copy of this resolution to Dr. White's family.

*Be it resolved*, that whereas Sidney Powers, one of our beloved and most loyal members, is absent from this meeting by reason of critical illness, we do hereby express our sympathy and our earnest hope for his speedy recovery.

*Be it further resolved*, that a copy of this resolution be spread upon the minutes of this meeting and that the president be requested to forward a copy of this resolution to Dr. Powers and to his family.

*Be it resolved*, that whereas the floods of Mississippi River have in the past caused great disasters and will do so in the future repeatedly unless controlled; and,

Whereas it is proposed in the Congress of the United States to spend hundreds of millions of dollars in effecting such control; and,

Whereas, the fundamental conditions determining the recurrent floods inhere in geological processes, familiar to geologists; and,

Whereas, effective control by engineering devices must be based upon a proper understanding of the fundamental conditions and of the geological processes concerned; therefore,

*Be it resolved*, that it is the sense of the American Association of Petroleum Geologists in annual convention assembled at San Francisco, California, that a comprehensive study of the Mississippi delta be undertaken by the Government of the United States; that such a study be carried out by an advisory committee of geologists directing field operations, and that any appropriations voted by Congress for the control of the floods of Mississippi River include provision for defraying the expense of a comprehensive geological study of the delta.

*Be it further resolved*, that the President of the United States be requested to appoint an advisory commission of geologists who shall be empowered to direct the prosecution of such geological study.

*Be it further resolved*, that a copy of this resolution be spread upon the minutes of this meeting and that the president be requested to forward a copy of it to the Honorable Herbert C. Hoover, Secretary of the Department of Commerce.

*Be it resolved*, that whereas active promotion of geologic work by the several oil-producing states and by the Federal Government is necessary to the continued success of commercial work in petroleum geology and that funds recently appropriated for such work by State Legislatures and Federal Congress are in many, if not most, cases so inadequate as seriously to interfere with active promotion of such work by State and Federal geologic surveys, the members of this Association individually and collectively seek such measures as may be proper and effective for the encouragement of appropriations of larger public funds for geologic work.

*Be it resolved*, that whereas the local committee for the New York Meeting of November, 1926, has graciously provided a revolving publication fund of \$4,114.84 for the Association, we do hereby express to the New York committee our appreciation and do hereby accept the responsibility of this fund as specified in the rules and agreement approved by the executive committee and the general business committee.

*Be it further resolved*, that a copy of this resolution be spread upon the minutes of this meeting and that the president be requested to forward a copy to the local committee for the New York meeting of November, 1926.

WALLACE E. PRATT, *Chairman*  
C. R. MCCOLLOM  
C. MAX BAUER  
HARRY A. AURAND

The resolutions were unanimously adopted.

T. S. Harrison presented the report of the audit committee.

#### REPORT OF THE AUDIT COMMITTEE

The audit committee has examined the certified account and financial statement of the treasurer as printed in the *Bulletin* for March, 1928, pp. 286-91, and approved the report.

THOMAS S. HARRISON, *Chairman*

FRITZ L. AURIN

GEORGE M. CUNNINGHAM

The report was accepted.

C. R. McCollom presented the report of the general business committee.

#### REPORT OF THE BUSINESS COMMITTEE

The general business committee recommends that the executive committee hereby be instructed to prepare, and submit to letter ballot, amendments to the constitution and by-laws as follows:

##### *Amendment to constitution:*

That there be added to Article III, Section 1 of the Constitution a provision for life membership for active members.

##### *Amendment to by-laws:*

That there be added to Section 1 of the by-laws a provision for the payment of \$300.00 in a lump sum, in return for life membership, to be used for a permanent investment fund, the income from which shall be devoted to the same purposes as the regular dues.

##### *Amendment to constitution:*

That there be added to Article 4, Section 6, a provision to read: The fiscal year of the Association shall correspond with the calendar year.

##### *Amendment to constitution:*

That Article VIII, Section 1, should be amended to include technical as well as regional sections of the Association.

The report was unanimously adopted in its entirety.

Mr. McCollom, representing the business committee, suggested that local geological societies consider the advisability of becoming regional sections of the American Association of Petroleum Geologists.

President Gester announced that the Society of Economic Paleontologists and Mineralogists had been recognized by the executive committee as an affiliated society.

President Gester announced the election of officers.

#### REPORT OF ANNUAL ELECTIONS

Nominations for officers of the Association were made in open meeting previously announced for that purpose, on Wednesday afternoon, in the Native Sons Auditorium. Inasmuch as only one man was nominated for each office and no other nominees were offered, it was moved and carried that the secretary

cast the ballot for the men nominated and these nominees were declared elected:

R. S. McFarland, of Tulsa, president

J. E. Elliott, of Los Angeles, first vice-president

David Donoghue, of Fort Worth, second vice-president in charge of finances

John L. Rich, of Ottawa, Kansas, third vice-president in charge of editorial work

The meeting was adjourned at 5:15 P. M.

DAVID DONOGHUE, *Secretary*



## Memorial

### THEODORE C. SHERWOOD, JR.

Theodore C. Sherwood, Jr., died in Roswell, New Mexico, March 31, 1928, at the age of 32 years, and was buried in Tulsa, Oklahoma, April 3.

He was born in Kansas City, Missouri, May 15, 1896, and finished high school at Manual Training High, Kansas City, Missouri. He matriculated in the University of Wisconsin in 1914 and in the Missouri School of Mines in Rolla, Missouri, in 1916. His studies were then interrupted for two years by the war.

At the outbreak of the war, when a majority of his classmates applied and were accepted for officers' training camps, Ted was hobbling on crutches with a broken leg—sustained in jumping from a roof. By fall he was recovered and in olive drab. He served with Headquarters Company, 314th Engineers, 89th Division, with rank of master engineer, junior grade. He spent nearly two years in the service, approximately 12 months of that time overseas in France and with the Army of Occupation in Germany. He took part in two major offensives, St. Mihiel and the Argonne, with sector duty on other fronts. His burial service at the grave was conducted by Tulsa Post No. 577, Veterans of Foreign Wars.

On August 22, 1917, he was married to Miss Ruth Green of Cuba, Missouri. Two children were born, Mary Ruth, age 7, who survives, and Theodore C., 3rd, who died at the age of 6 months and is buried in Tulsa.

After being discharged from the army in 1919 Ted resumed his studies at the Missouri School of Mines, and was graduated in 1920. His first field work was under Guy Henry Cox for the Josey Oil Company, then of Okmulgee, Oklahoma, and continued from the spring of 1920 until the death of Dr. Cox in an automobile accident in August, 1922.

That tragic event changed the trend of Sherwood's work, as it put him into subsurface work for the Josey Oil Company, a line of work for which he had shown aptitude, and which was just beginning to command a place as an important factor of geological work. He made Bristow his headquarters while with Dr. Cox, moving to Okmulgee at his death. He was with Josey two and one-half years.

In February, 1923, Ted left Josey to join the geological staff of Waite Phillips Company, in Tulsa, as a subsurface man. He was with Waite Phillips two and a half years during the meteoric rise of that company, a considerable part of the company's most profitable acreage being acquired under his recommendation.

It was as a subsurface geologist that Ted found himself. At less than 30 years of age he was regarded as one of the outstanding subsurface men of Oklahoma. His work in carrying the correlations of the Dutcher and Cromwell sand series from north-central Oklahoma south through Seminole to the Ar-

buckle Mountains in 1925 was an exceptionally fine piece of work, and has in the main been verified by later developments.

On November 1, 1925, Ted joined the geological department of Phillips Petroleum Company of Bartlesville, Oklahoma, moving to that place.

In 1924 in Tulsa he had been stricken with incipient tuberculosis, but had made an apparent recovery after six weeks of rest and milk diet. In March, 1927, immediately after the convention of the American Association of Petroleum Geologists in Tulsa he had an attack of influenza, and his health remained unsatisfactory from that time on. In June it became apparent that he was suffering from tuberculosis, and Phillips Petroleum Company rushed him with his family to Roswell, New Mexico. Though unable to work he was carried in the employment of the company until his death. By October his condition had become such that he was put to bed, where he remained for six months, until the end. The end came with only a few days' warning. He had built up weight to 160 pounds. A week before his death his family were rejoicing in an apparent improvement.

He was a member of the American Legion, the Tulsa Geological Society and the American Association of Petroleum Geologists.

He is survived by his widow and daughter Mary Ruth, his father, T. C. Sherwood, Sr., and brother, John N., all of Tulsa.

Ted Sherwood was characterized by a rare faculty for making friends. The geological fraternity has lost one of its most lovable members, as well as a brilliant mind.

EMMETT L. ARNOLD

## AT HOME AND ABROAD

### CURRENT NEWS AND PERSONAL ITEMS OF THE PROFESSION

LOUIS ROARK, formerly chief geologist of the Kingwood Oil Company at Okmulgee, resigned April 1 and has opened an office as consulting geologist. Mr. Roark's address is 926 N. Collins, Okmulgee, Oklahoma.

WILL F. EARL, of the geological department of the Transcontinental Oil Company, has been transferred from Coalgate to Okemah, Oklahoma.

B. COLEMAN RENICK, consulting geologist at Palestine, Texas, is temporarily doing geological work for the Roxana Petroleum Corporation in the Gulf Coast region. His address is care of Roxana Petroleum Corporation, Post Dispatch Building, Houston, Texas.

T. C. SHERWOOD, JR., formerly geologist of Tulsa, Oklahoma, died at Roswell, New Mexico, March 30, 1928. Tuberculosis was the cause of his death.

D. DALE CONDIT, consulting geologist, 321 Dorset Avenue, Chevy Chase, Washington, D. C., returned last March from a business trip of three months into remote Rhodesia and other parts of South Africa.

CHESTER W. WASHBURN, geologist, 27 William Street, New York City, returned from Venezuela in March, and departed for Sao Paulo, Brazil.

R. B. ROARK is now general production superintendent of the northern division (Kansas, Oklahoma, and the Amarillo area) of the Roxana Petroleum Corporation at Tulsa, Oklahoma.

J. WITHERS CLAY, formerly geologist with the Woodley Petroleum Company of Shreveport, Louisiana, is engaged in consulting work in Brownwood, Texas. His address is 407 West Adams Street.

At the instance of the Japanese Embassy, the Department of State, Washington, D. C., is sending out announcements of the World Engineering Congress to be held at Tokio, Japan, in October, 1929, under the auspices of the Kogakukai (Engineering Society of Japan). Associations and individuals collaborating in engineering in all branches are invited. Further information may be obtained from Elmer A. Sperry, chairman American Committee, World Engineering Congress, 29 West 39th Street, New York City. A. A. P. G. members planning to attend the Congress will please communicate with J. P. D. Hull, Box 1852, Tulsa, Oklahoma.

C. E. DOBBIN, of the U. S. Geological Survey, has moved his office from Washington to Denver, where he will act as consulting geologist to the leasing section of the Survey in the Rocky Mountain states, Oklahoma, and California. His address is 212 Custom House Building, Denver, Colorado.

E. L. ROARK, with Jarvis and Holm, Inc., for the past several years, is also doing geological work for the Winona Oil Company, Tulsa, Oklahoma.

The American Institute of Mining and Metallurgical Engineers will hold its fall meeting in Boston, Massachusetts, August 29-31, 1928. The principal topic will be geophysical methods of prospecting. An excursion to Newfoundland is planned for September 1-16. Address the secretary, 20 West 39th Street, New York City.

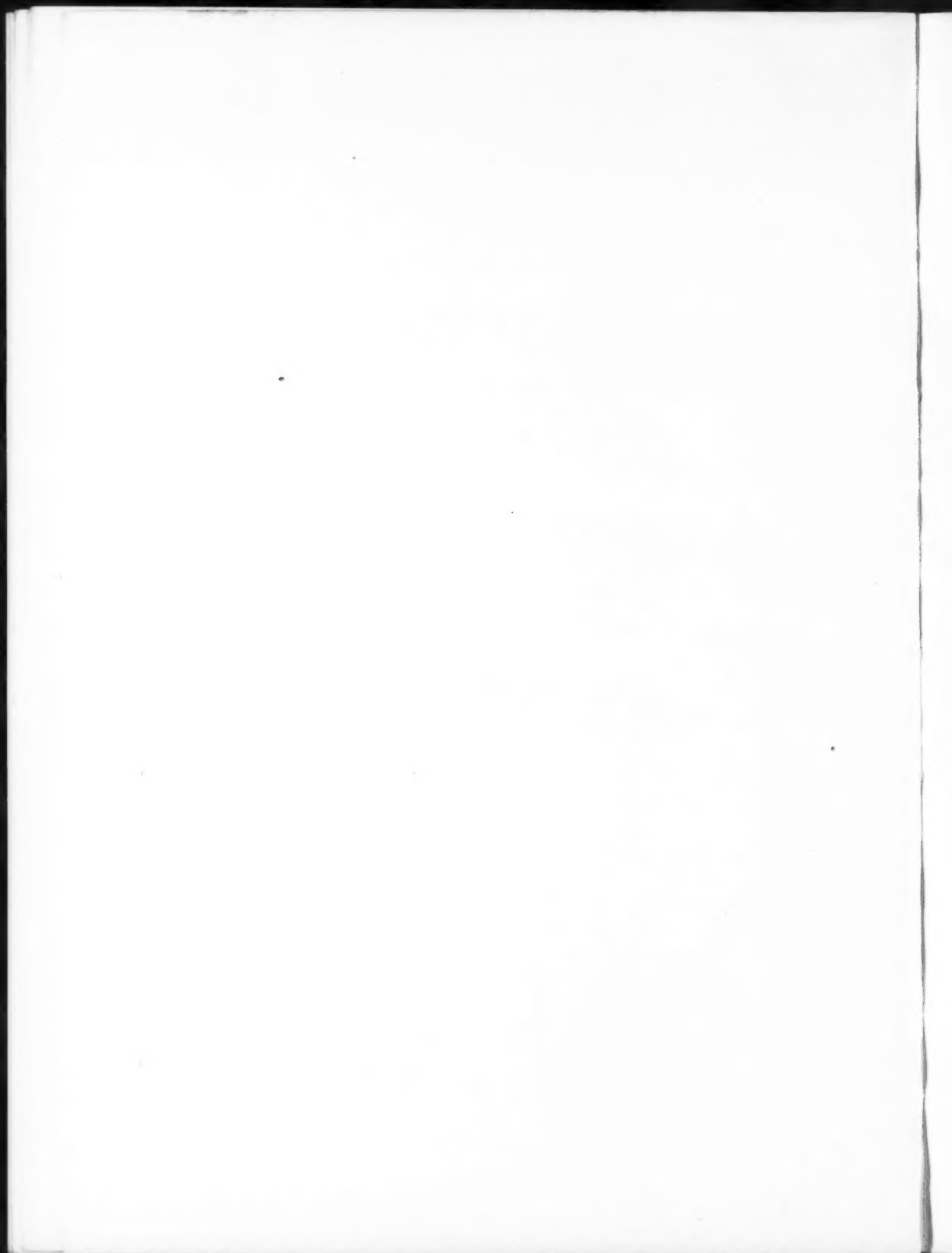
SIDNEY POWERS, consulting geologist for the Amerada Petroleum Corporation, Tulsa, Oklahoma, has been seriously ill for several months.

The Association's new book, *Theory of Continental Drift*, is now available from headquarters at \$3.50 a copy, postpaid. This is the first publication issued under the new revolving publication fund established by the New York local committee for the fall meeting of 1926.

L. DUDLEY STAMP had a paper on "The Connection between Commercial Oil Deposits and Major Structural Features with Special Reference to Asiatic Fields" in the *Journal of the Institution of Petroleum Technologists* for February, 1928, pages 28-63.

The *Bulletin of the Geological Society of America*, Vol. 38, No. 4, December, 1927, contains the following papers of special interest to petroleum geologists: "Steep Subsurface Folds Versus Faults," by Charles T. Kirk and T. E. Weirich; "Nonmarine Tertiary Deposits of Colombia," by F. M. Anderson; and "Tertiary Stratigraphy and Orogeny of the Northern Punjab," by R. V. V. Anderson.





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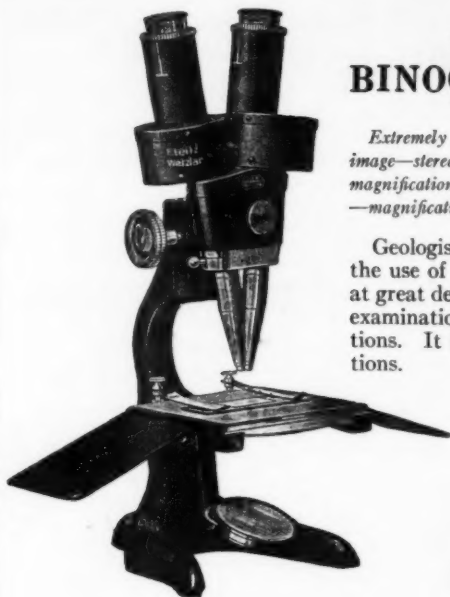
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